

DEVELOPMENT OF AN INTERACTIVE GRAPHIC PACKAGE FOR TIME TABLING OF A LARGE BUS TRANSIT NETWORK

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in Partial Fulfilment of the Requirements
for the Degree of
MASTER OF TECHNOLOGY*

by
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to the
Department of Civil Engineering
Indian Institute of Technology, Kanpur
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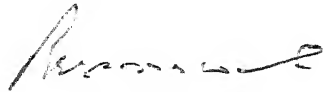
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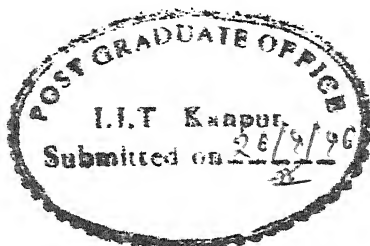
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CERTIFICATE

This is to certify that the thesis "DEVELOPMENT OF INTERACTIVE GRAPHIC PACKAGE FOR TIME TABLING OF A LARGE BUS TRANS NETWORK" submitted by AVADHESH KUMAR in partial fulfillment of the requirements for the degree of Master of Technology of Indian Institute of Technology Kanpur, is a bonafide research work carried out by him under my supervision and guidance. The work embodied in this work has not been submitted elsewhere for the award of degree.

September 26, 1996


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Heartiest thanks are hereby expressed to my colleagues and friends who helped me in carrying out this work and made my stay at I.I.T. Kanpur memorable one.

Avadhesh Kumar

ABSTRACT

In the planning process of a Bus Transit Network for an urban area, the last stage is the preparation of the Time Table for the buses on different routes which are optimally decided in the previous stages of the process. This Time Table should be consistent with all the practical constraints regarding the availability of terminals, rest of the crew, changing the crew etc. which are covered under the labour laws.

The development of the present package is aimed to assist the Transport Planner in preparing the Time Table for a large Bus Transit Network. This package can help the Planner in fixing the departure times for all the buses decided to ply on different routes of the network, from one terminal to other. This also gives the departure times at intermediate stops being consistent with all the practical constraints.

This package also shows the graphic display of the operation strategy of the buses showing the departure times of different buses at the terminals.

The package is UNIX based and fully interactive to allow the user to see the input and output on the graphic screen. The working of the package is observed quite logical and user friendly.

The field data of some routes of Delhi Bus Network are used to test the program. The output is found to be quite relevant to the actual operation strategies.

CONTENTS

	Page
ABSTRACT	iv
LIST OF FIGURES	vii
LIST OF TABLES	viii
1. INTRODUCTION	
1.1 General	1
1.2 Statement of the Problem	2
1.3 Literature Review	2
1.4 Objective and Scope of Present Work	3
1.5 Outline of the Report	3
2. PLANNING PROCESS OF THE BUS TRANSIT NETWORK	
2.1 General	5
2.2 Demand Estimation	5
2.3 Routing	7
2.3.1 Generation of Alternative Routes	7
2.3.2 Evaluation of Alternative Routes and Selection of Optimal Route Network	8
2.4 Scheduling	10
2.4.1 General	10
2.4.2 Allocation of the Buses to the Routes	16
2.5 Time Tabling	18
3. MODEL DEVELOPMENT	
3.1 Problem Formulation	20
3.1.1 General	20
3.1.2 Input for the Program	20
3.2 Program Logic and Development	24
3.2.1 Generation of Departure Times at Terminals	24

3.2.2	Operational Characteristics of the Buses	27
3.2.3	Assignment of Buses to the Generated Departure Times	30
3.2.4	Output of the Program	36
3.2.4.1	Output in Tabular Form	36
3.2.4.2	Graphic Simulation Model	36
4.	PROGRAM WORKING AND APPLICATION	
4.1	Package Illustration	38
4.2	Input for the Program	39
4.3	Execution of the Program	39
4.4	Execution of Graphic Simulation Model	41
4.5	Output of the Program	41
4.6	Application to Some Routes of Delhi	52
5.	SUMMARY AND CONCLUSIONS	
5.1	Summary and Conclusions	104
5.2	Scope for Future Study	106
	REFERENCES	107

LIST OF FIGURES

Figure No.		Page
2.1	FLOW CHART OF PLANNING PROCESS IN BROAD VIEW	6
2.2	FLOW CHART FOR OPTIMAL ROUTING	11
2.3 (a)	NUMBER OF TRIPS AND OPERATION COST RELATIONSHIP	13
2.3 (b)	NUMBER OF TRIPS AND WAITING COST RELATIONSHIP	14
2.3 (c)	NUMBER OF TRIPS AND TOTAL COST RELATIONSHIP	15
2.4	FLOW CHART OF ALLOCATION OF BUSES TO THE ROUTES	17
3.1	FLOW CHART OF GENERATION OF DEPARTURE TIMES AT THE TERMINALS	25
3.2	FLOW CHART FOR DETERMINING THE EFFECTIVE MAXIMUM TRIPS	29
3.3	FLOW CHART OF PROCEDURE OF ASSIGNMENT OF BUSES TO DEPARTURE TIMES	34
3.4	FLOW CHART OF MODEL DEVELOPMENT IN BROAD VIEW	37
4.1	WELCOME SCREEN	42
4.2	OUTPUT OPTION SCREEN	43
4.3	INPUT OPTION SCREEN	44
4.4	'ERROR MESSAGE AND DISPLAY OF FILES IN PRESENT DIRECTORY' SCREEN	45
4.5	'OUTPUT OF THE PROGRAM' SCREEN	46
4.6	GRAPHIC DISPLAY OF MOVEMENT OF BUSES	47
4.7	GRAPHIC DISPLAY FOR BUS NO. 1	48
4.8	GRAPHIC DISPLAY FOR BUS NO. 2	49
4.9	GRAPHIC DISPLAY FOR BUS NO. 3	50
4.10	GRAPHIC DISPLAY FOR BUS NO. 4	51

LIST OF TABLES

Table No.		Page
4.1	INPUT DATA AND DESCRIPTIVE PARAMETERS FOR THE ROUTES	53
4.2	TIME TABLE FOR ROUTE NO. 1	55
4.3	TIME TABLE FOR ROUTE NO. 2	57
4.4	TIME TABLE FOR ROUTE NO. 3	59
4.5	TIME TABLE FOR ROUTE NO. 4	61
4.6	TIME TABLE FOR ROUTE NO. 5	62
4.7	TIME TABLE FOR ROUTE NO. 6	64
4.8	TIME TABLE FOR ROUTE NO. 7	66
4.9	TIME TABLE FOR ROUTE NO. 8	69
4.10	TIME TABLE FOR ROUTE NO. 9	71
4.11	TIME TABLE FOR ROUTE NO. 10	73
4.12	TIME TABLE FOR ROUTE NO. 11	75
4.13	TIME TABLE FOR ROUTE NO. 12	76
4.14	TIME TABLE FOR ROUTE NO. 13	77
4.15	TIME TABLE FOR ROUTE NO. 14	78
4.16	TIME TABLE FOR ROUTE NO. 15	79
4.17	TIME TABLE FOR ROUTE NO. 16	81
4.18	TIME TABLE FOR ROUTE NO. 17	82
4.19	TIME TABLE FOR ROUTE NO. 18	83
4.20	TIME TABLE FOR ROUTE NO. 19	86
4.21	TIME TABLE FOR ROUTE NO. 20	88
4.22	TIME TABLE FOR ROUTE NO. 21	90
4.23	TIME TABLE FOR ROUTE NO. 22	91

4.24	TIME TABLE FOR ROUTE NO. 23	93
4.25	TIME TABLE FOR ROUTE NO. 24	95
4.26	TIME TABLE FOR ROUTE NO. 25	97
4.27	TIME TABLE FOR ROUTE NO. 26	99
4.28	TIME TABLE FOR ROUTE NO. 27	100
4.29	TIME TABLE FOR ROUTE NO. 28	101
4.30	TIME TABLE FOR ROUTE NO. 29	102
4.31	TIME TABLE FOR ROUTE NO. 30	103

1. INTRODUCTION

1.1 GENERAL

An efficient transportation system is considered to be of utmost importance for the development of a city. In the developing countries like India, the cities are growing in size and population rapidly. In such a case, the need of providing an efficient public transportation system is quite inevitable.

Two most important modes of public transportation are Bus Transit system and Rail Transit system. Each mode has its own importance and role to play in providing the transit facilities. These may be considered complimentary to each other.

The bus transit is the most prevalent mode and carries over 70 percent of all transit travel. Its main advantage is the ability to be routed along any street or highway. Though the travel by buses is a little bit inconvenient as compared to the rail transit but its attributes of reliability, availability, flexibility and economy, indicate that it will remain as the most popular mode of public transportation.

The urban mass transportation system consists of a complex arrangement of various public transportation modes and there are many factors to be considered to achieve efficient and effective transit services. As stated earlier, the bus system is the most important, therefore it is imperative to plan and operate the bus transit system in the most effective way. The operation strategy should be convenient for the commuters as well as operators.

1.2 STATEMENT OF THE PROBLEM

In the planning process of a bus transit network, first of all an optimal route network is determined on the basis of the given demand with the help of different criteria. After that an optimal fleet size on each route is decided based on the economic criteria from the viewpoint of the operator as well as the commuters. Required headway is also determined for the route. After having decided these all, the last but not the least important stage is the preparation of the Time Table for the buses on each route. Efficiency of a transportation system largely depends upon the Time Tabling, and hence it should be prepared carefully keeping in mind the convenience of the commuters as well as the operator. Any deficiency in the Time Table may lead to the crash of the whole system and purpose of the system will be destroyed.

The present work emphasizes on an efficient and effective Time Tabling which is suited to all practical conditions prevailing in the country.

1.3 LITERATURE REVIEW

The success of a transit system mainly depends on the proper and rational operation strategy, but general practice is to carry out the study on scheduling of the system which does not include the actual operation strategy in terms of time tabling. In other words time tabling is done on a trivial basis without giving much emphasis on this aspect. But for a large system a quick and

rational tool is necessary and it is possible only with the help of a computer.

Onail (1984) distinguishes some methodologies for bus network namely manual design, Market Analysis Project (MAP), System Analysis with Interactive Graphics (SAIG) etc. MAP is very similar to system analysis where bus routes and frequencies are designed manually but analyzed by the computer. Marwah and Patnaik (1984) have developed a method in which selection of routes and frequencies are done simultaneously for Kanpur Bus Transportation.

Detailed studies have been made by Lankain and Saalman (1967) on routing and scheduling of city bus network. A demand oriented network generation was presented by Moorthy (1989). An interactive modelling approach, to solve the practical problem of bus route network design, is designed by Budhesuden, Ranjithan and Singh (1987).

1.4 OBJECTIVE AND SCOPE OF THE PRESENT WORK

The sole objective of this research project is to develop an interactive graphic package to prepare the Time Table for a large bus transit network. The aim is to assist the planner in preparation of the Time Table quickly, taking all the conditions into account which are likely to be encountered in the field and the labour laws prevailing in the country.

1.5 OUTLINE OF THE REPORT

The structure of the report is as follows: Chapter-2 describes the planning process of a Bus transit network. Chapter-3

describes the problem formulation, program logics, algorithms and flowcharts and program development. Chapter-4 explains the working of the program, application of the package to some routes of Delhi Metropolitan area. Chapter-5 contains a brief summary of the report, conclusion and scope for future work.

2. PLANNING PROCESS OF THE BUS TRANSIT NETWORK

2.1 GENERAL

The planning process of a bus transit network involves various stages viz. demand estimation, alternative route generation, evaluation and optimal route network selection, scheduling and time tabling.

Demand for a bus transit network depends upon the characteristics of the public transport, land use characteristics and socio-economic characteristics. For generation of alternative routes, we can use existing routes or the new routes may be proposed. Based on some criteria, an optimal route network is selected. On this optimal route network, required number of trips are determined which satisfy the demand. This is known as scheduling. Now fixing a desired headway for a certain level of service, fleet size is decided. Finally a Time Table is prepared to ply these buses, to fulfill the requirements of the fixed headway and certain other practical conditions mentioned earlier. A flow chart (Figure 2.1) shows the various stages in a broad way.

2.2 DEMAND ESTIMATION

Demand for a transit system is represented by the number of passenger trips from origin to destination by that transit mode. For estimation of the demand, the area under consideration is divided into various zones of similar activities like business area, industrial area, academic area, residential area etc. and

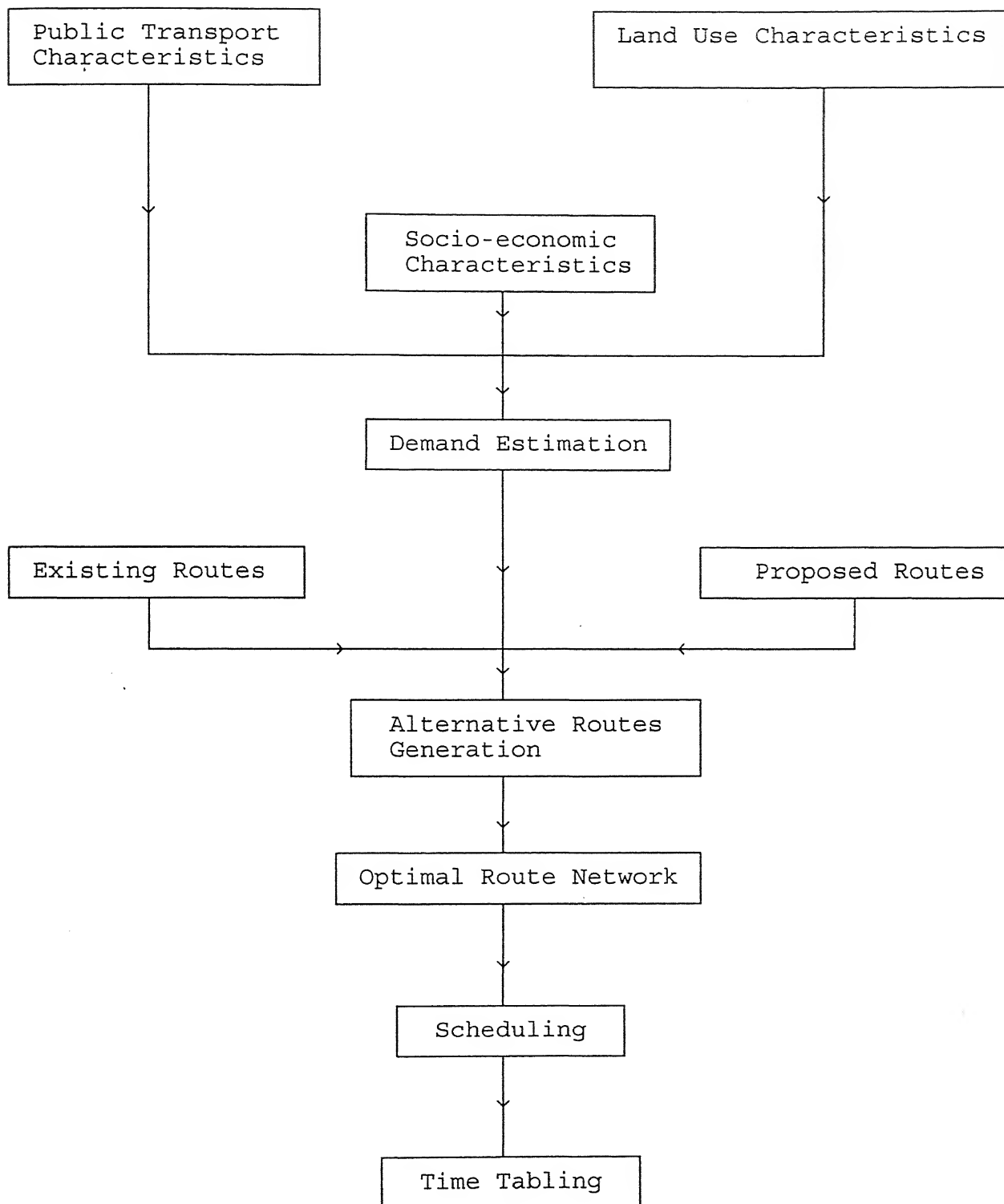


Fig. 2.1 PLANNING PROCESS IN BROAD VIEW

then survey is conducted to collect the data on trips generated from the area and trips attracted to the area. Also the trips from one zone to other are determined and presented in a tabular form which is known as demand matrix or origin-destination (O-D) matrix. This matrix is projected to the future year which we take as design year.

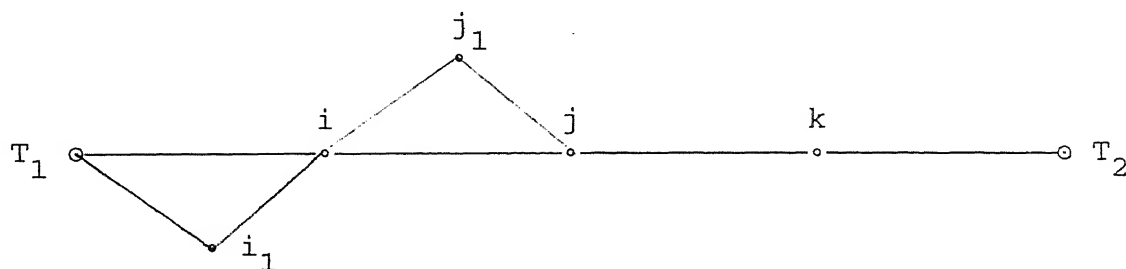
2.3 ROUTING

2.3.1 Generation of Alternative Routes

Two nodes having the largest demand are fixed as terminals. Now various alternative routes are generated between these two nodes. The following procedure is adopted in generation of the alternative routes (Ref. M. Dashora, 1991; B.R. Marwah, 1994):

I. Find the shortest path between the terminals.

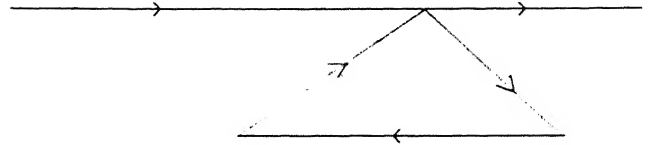
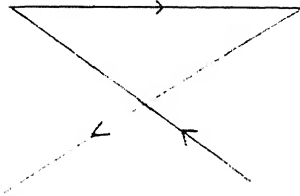
Suppose T_1 and T_2 are two terminals and i, j, k etc. are intermediate nodes.



II. Another route deviating from the shortest path and passing through the node i_1 or j_1 can be selected but then the length of this route should not be greater than 1.5 times the shortest route.

III. Some important nodes on shortest path are to be defined which must be on the alternative routes.

- IV. Route should be such that there is no backtracking as shown below:



- V. If the terminal nodes are very near to each other, the route between them will not be provided directly but it should pass through some other nodes in the network.

2.3.2 Evaluation of Alternative Routes and Selection of Optimal Route Network

The various alternative routes generated in the previous section are evaluated based upon some criteria described below, and an optimal route network is finally selected.

2.3.2.1 Evaluation criteria (Ref. M. Dashora, 1991)

- I. Maximum demand satisfied on the route: The route which is satisfying the maximum demand can be selected. But as a number of nodes are excluded from the shortest path, it will seldom select the shortest path which might be the best option.
- II. Maximum passenger-kilometers: This criteria maximizes the passenger-kilometers over all the route alternatives. But this criterion does not make any difference between a longer route with lower passenger flow and a shorter route with higher passenger flow.
- III. Maximum passenger-kilometers/route length: This criterion maximizes the total passenger-kilometer per unit route

length. By this criterion, the routes which has a large difference in passenger density on different links, may be selected but in such a case most of the part of the route will be unutilized.

IV. Minimum coefficient of variation: Coefficient of variation is the ratio of standard deviation to the mean of the link flows on the route. Minimum coefficient of variation gives the best route.

V. Maximum link utilization: This, for a link, is defined as the ratio of the link flow to the maximum link flow. But this criteria does not take the whole route into account in one instance.

VI. Maximum route utilization coefficient: Route utilization coefficient is defined as the ratio of summation of the product of link flow and link length to the product of maximum link flow and total route length. The maximum route utilization coefficient gives the best alternative.

After fixing an optimal route network, adequate demand is assigned to each route. The demand satisfied by a route is deleted from the Origin-Destination matrix. The process of identifying the terminals and generation and selection of new routes will be repeated until the appreciable demand is satisfied. The whole routing procedure can be summarized in the following steps (Ref. M. Dashora, 1991):

- (i) Generate or have a fixed desire travel matrix (i.e. a matrix which gives a good idea of the potential demand in every origin destination relation.

- (ii) Street network which consists of all the links on which the vehicle could possibly ply (i.e. the road network of the city).
- (iii) Identify the nodes which are the major producer of trips (i.e. whose production is greater than 1.5 times the average).
- (iv) Select a pair of terminals in the network using information given in Step (iii) or otherwise.
- (v) Generate shortest path as first alternative between the terminals.
- (vi) Subsequent alternatives are then generated as described earlier.
- (vii) An optional route is selected based upon the criteria discussed earlier.
- (viii) Assign the adequate demand to this route and delete this demand from O-D matrix.
- (ix) Repeat Step (iv) through (viii), till appreciable demand from O-D matrix is satisfied. Thus a set of routes is generated for entire network.

A flow chart of the routing procedure is also shown (Figure 2.2).

2.4 SCHEDULING

2.4.1 General

After fixing adequate demand to each route of the network, we have to determine the optimal number of trips required for each

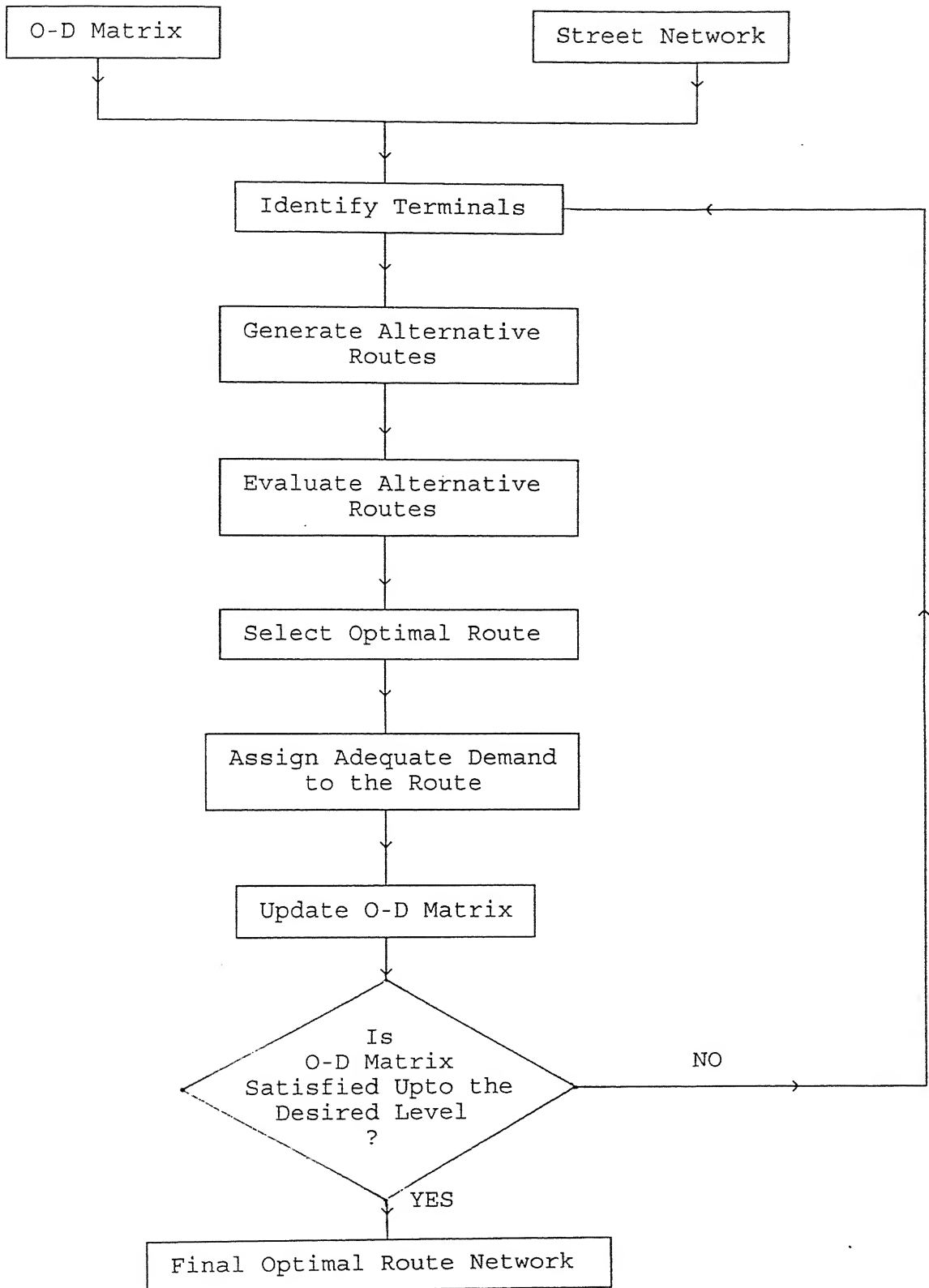


Fig. 2.2 FLOW CHART FOR OPTIMAL ROUTING

route, and finally, based on a desired headway, fleet size is determined.

Number of trips depends on the maximum link flow, average link flow, capacity of the bus, load factor (ratio of number of passengers to the bus capacity) to be used, desired level of service etc. Optimal number of trips are decided based upon the total cost (a balance between commuters' waiting cost and operation cost). The operation cost increases with increase in number of trips and waiting cost decreases with increase in number of trips. Thus, the optimal number of trips is that which minimizes the total cost. Figure 2.3 shows the variation of the total cost with number of trips (Ref. M. Dashora, 1991).

Minimum Number of Buses:

Let N_1 and N_2 be the number of trips required on the route, then

$$N_1 = \frac{\text{Maximum link flow on the route}}{\text{Bus capacity} \times \text{Maximum load factor } (\approx 1.5)}$$

and

$$N_2 = \frac{\text{Average link flow}}{\text{Bus capacity}}$$

Then maximum of N_1 and N_2 is taken as minimum number of trips and hence minimum number of buses required

$$= \frac{\text{Minimum number of trips}}{\text{Time period}} \times \text{Round trip time}$$

where round trip time is the total time which the bus takes to travel the route and layover time. Time period is the time for which the scheduling is being done.

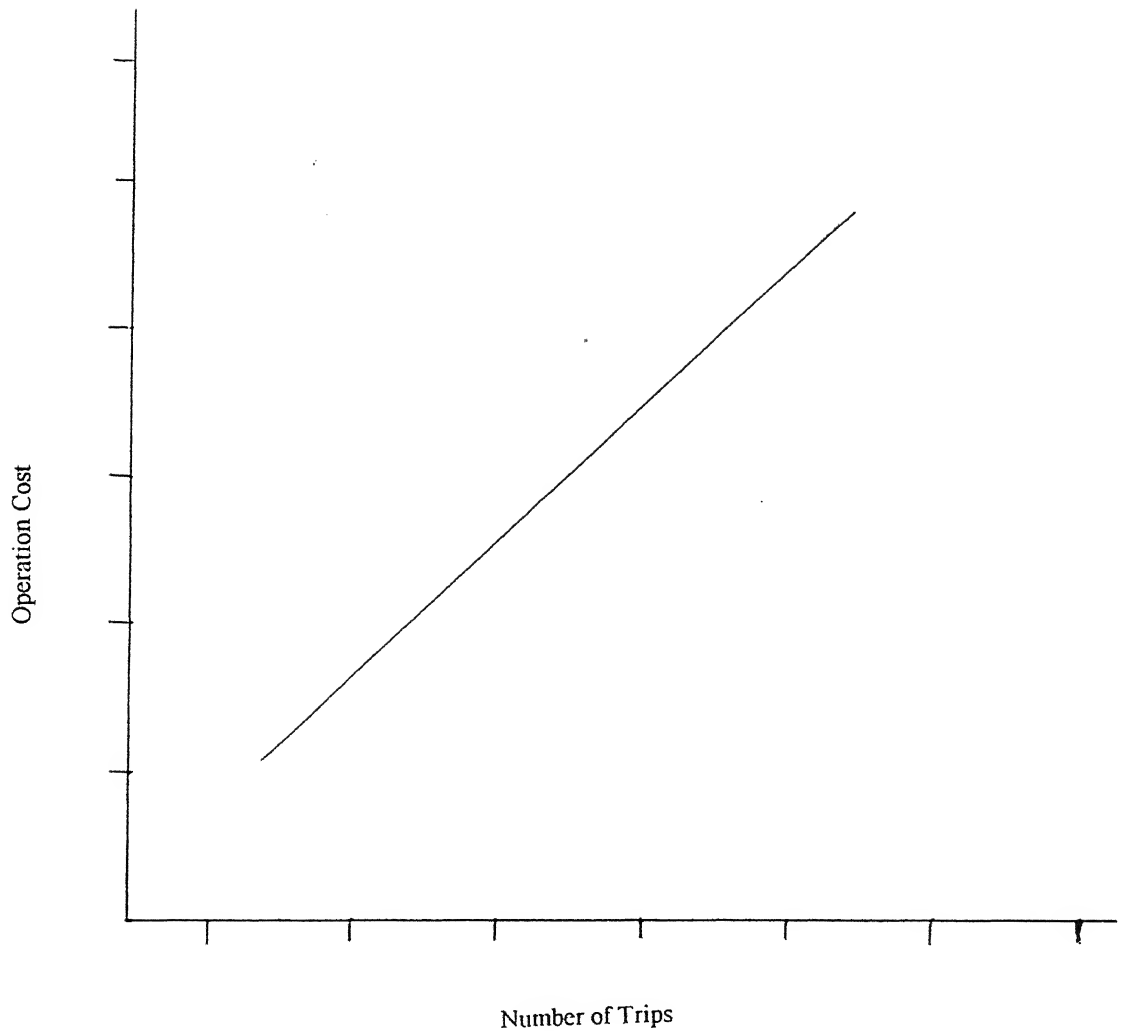


Fig. 2.3(a) NUMBER OF TRIPS AND OPERATION COST RELATIONSHIP

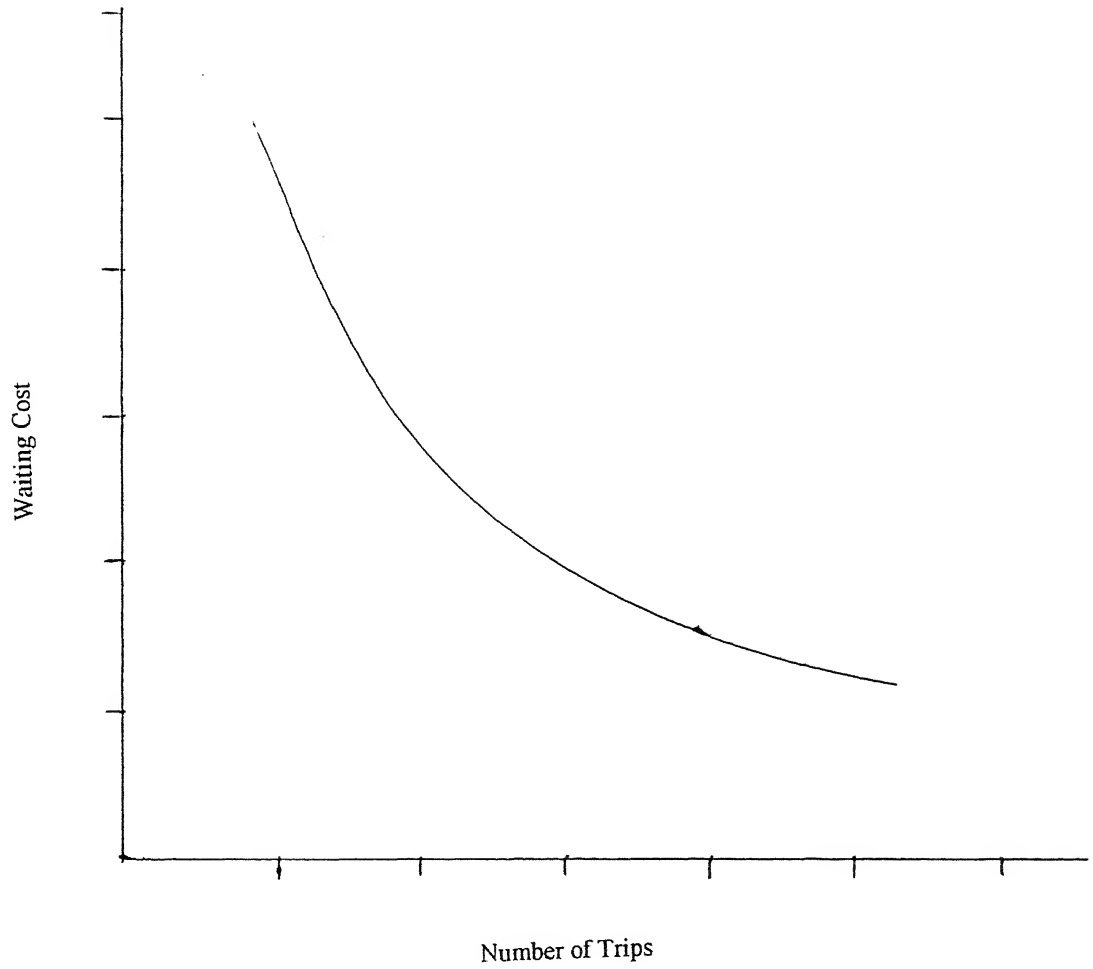


Fig. 2.3(b) NUMBER OF TRIPS AND WAITING COST RELATIONSHIP

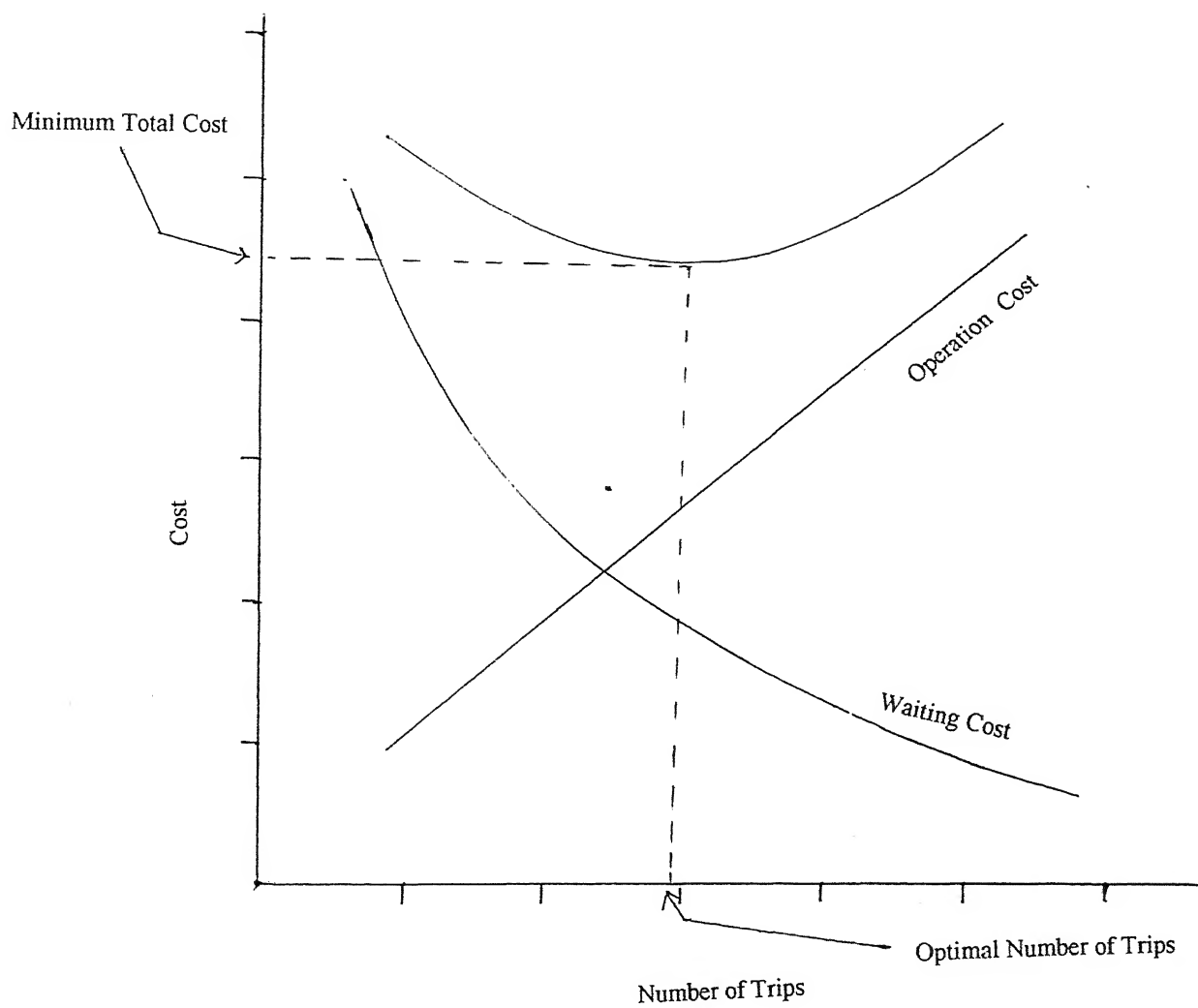


Fig. 2.3(c) NUMBER OF TRIPS AND TOTAL COST RELATIONSHIP

Maximum Number of Buses:

Maximum number of the buses required on the route is determined as follows:

Let N_3 is the maximum trips required on the route, then

$$N_3 = \frac{\text{Maximum link flow}}{\text{Bus capacity}}$$

and hence maximum number of buses

$$= \frac{N_3}{\text{Time period}} \times \text{Round trip time}$$

2.4.2 Allocation of the Buses to the Routes

(Ref: M. Dashora, 1991)

The allocation of transit units (buses) to the network is done based upon the idea that:

- (i) Every route should be allocated a minimum number of buses, depending upon the demand served by the route.
- (ii) Every route should be allowed a maximum number of buses depending upon the demand served by the route beyond which allocation will not be feasible.
- (iii) Between minimum and maximum allocation, every unit should be allocated to the 'best route'. The best route is one for which "Additional Bus Allocation Factor (i.e. saving in waiting time/increased cost of operation)" is maximum.

The procedure of allocating the additional buses over the minimum number of buses is described in the following steps:

- (i) Calculate the total minimum and total maximum number of buses required for each route at the given level of service and

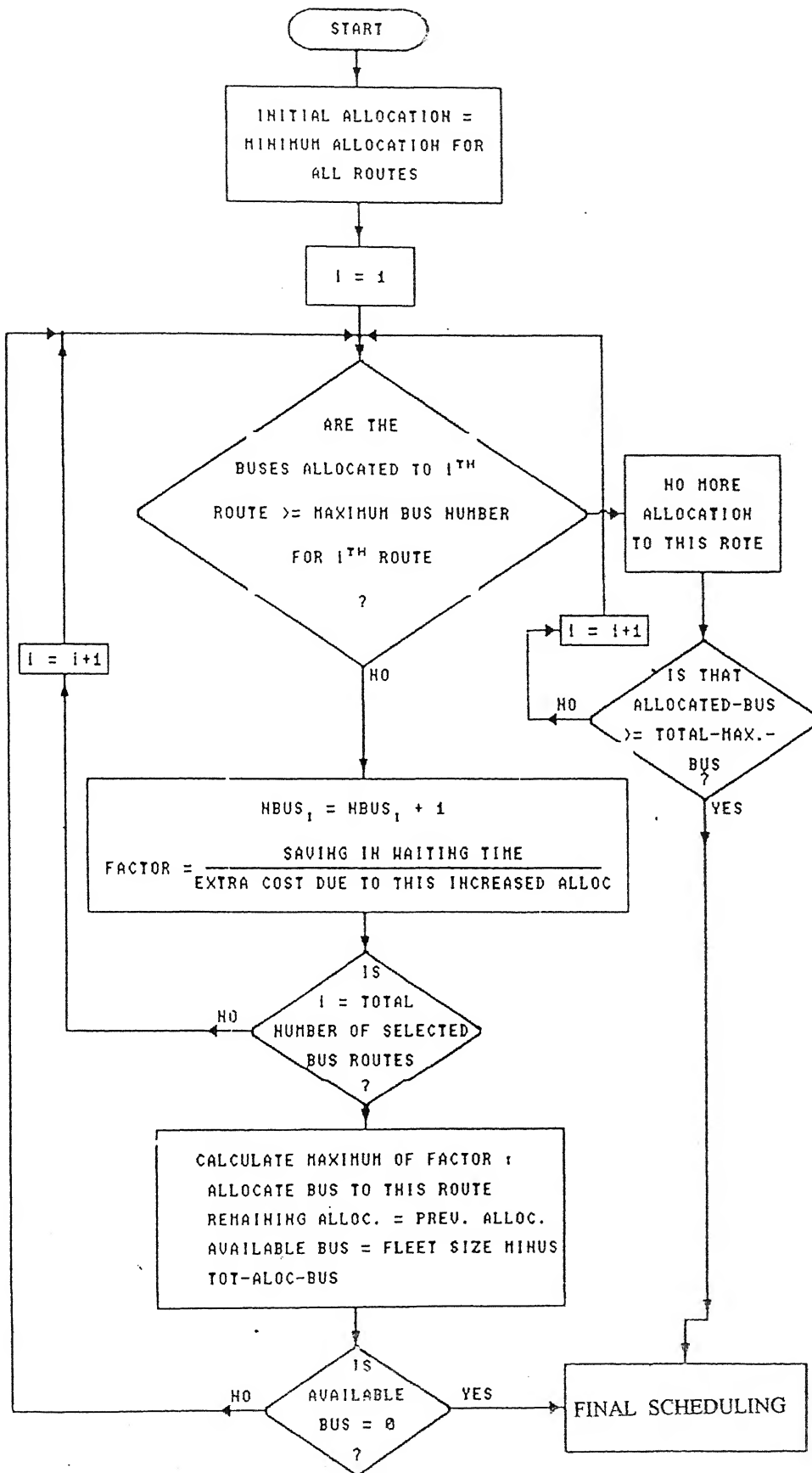


Fig. 2.4 FLOW CHART OF ALLOCATION OF BUSES TO THE ROUTES

therefore total minimum and maximum number of buses required for the system.

- (ii) Allocate the minimum number of buses to each route and compare total minimum allocation to fleet size. Then
 - (A) If fleet size is less than the total minimum allocation, then:
 - (a) Either increase the fleet size to meet the required schedule.
 - (b) OR if (a) is not possible then start removing the buses from worst route (having minimum Additional Bus Allocation Factor) till the entire given fleet size is allocated.
 - (B) If fleet size is between total minimum number and maximum number of buses required, then start allocating buses one by one to the 'best route' until entire given fleet size is allocated.
 - (C) If the fleet size is more than the total maximum number of buses required then:
 - (a) Either remove the extra buses and deploy them somewhere else.
 - (b) OR if (a) is not the choice, continue to allocate the buses to the 'best route' until the entire fleet size is allocated.

The whole procedure is shown in flow chart also (Figure 2.4).

2.5 TIME TABLING

The last stage of the planning process of the bus transit network is time tabling which is consistent with actual operation

strategies. This stage consists in fixing the departure times of the buses at the terminals and intermediate stops on each route of the network. This requires fleet size, off peak and peak headway, start and end time of operation in a day etc.

Fleet size is determined as explained in scheduling stage, headway is fixed up based on the desired level of service which in turn depends on the waiting time of the passengers. Generally headway is taken as twice the waiting time allowed. This is determined for both, off peak and peak period. Certain other practical constraints like rest to the crew, crew change, route type, availability of terminal etc. also govern the actual time tabling and operation strategies.

This stage is explained in detail in the next chapter.

3. MODEL DEVELOPMENT

3.1 PROBLEM FORMULATION

3.1.1 General

As the government is tending towards privatization, individual operator takes different route of the network. Based on the demand, certain number of buses are licensed to operate on a route for a certain operation period from morning to evening subject to various practical constraints related to labour laws etc. prevailing in the country.

For the successful operation of the bus system, an efficient time table for each route is of utmost important. It consists in deciding the departure times of each bus at the terminals, for all the routes along with satisfying all the constraints.

In the present work, an attempt has been made to develop a software which prepares such a time table which fulfills all the aforesaid requirements. The graphic simulation model shows the movements of the buses at their departure times, from one terminal to other on the graphic screen.

3.1.2 Input for the Program

3.1.2.1 Route Characteristics

Different routes of the network may have the different characteristics which influences the time table for the routes. Following are the characteristics which are taken into consideration in the present software.

(a) Type of the route: Type of a route is related to the availability of the terminals on the route and their positions, described as below:

TYPE I : A route, which is straight i.e. non-circular, and has a terminal at its one end only. There may be a terminal at its each end but being located in a congested area, e.g. in CBD, one of the terminal may not have adequate space for the rest and crew change. Sometimes, to minimize the dead kilometerage for the private operators, it is desirable to originate all the buses from one of the terminals only. In all such cases, the buses can be stored at one of the terminals only, for the rest and crew change. At start, all the buses originate from one of the terminals only.

TYPE II : This is a route which is straight and has one terminal at its each end. In such a case, the buses can be stored at any of the terminals for the rest and crew change. At the start, half of the buses originate from one terminal and half from the other and come to respective terminal at the end.

TYPE III: A route, which is circular, is designated as Type III route. This type of route has origin and destination terminals coinciding with each other. Thus there is only one terminal and the buses run in both, clockwise and anticlockwise directions, but a particular bus retains the same direction throughout the operation period of the day. Half of the buses run in clockwise

direction and half in anticlockwise direction.

(b) Travel time: It is the average journey time taken by a bus, from one terminal to other in case of Type I and Type II routes, and time taken in completing a round in case of Type III routes.

(c) Interstop travel time: It is the travel time taken by a bus between the adjacent intermediate stops lying on the route.

(d) Layover time: This is the halt time at the terminals. The magnitude of the layover time depends on the length of the route and trip travel time. It is kept generally of the order of 5 to 10 minutes.

3.1.2.2 Bus characteristics

Total number of the buses which are licensed for a particular route, is an input for the program. Only these buses are deployed on this route to run at desired frequency. Different routes of the network may have different number of buses and for these buses, the time table is prepared for different routes.

3.1.2.3 Operational strategies and practical constraints

The following operation strategies and constraints are incorporated in the time table as input:

(a) Start time: It is the departure time of the first trip from a terminal.

(b) Mid time: The hours of the day when headway changes from off peak to peak.

(c) End time: It is the possible departure time of the last trip from a terminal. Any trip can start at or before this time only.

(d) Headway: A certain headway is fixed up to operate the buses along a route. As the demand is not uniform throughout the

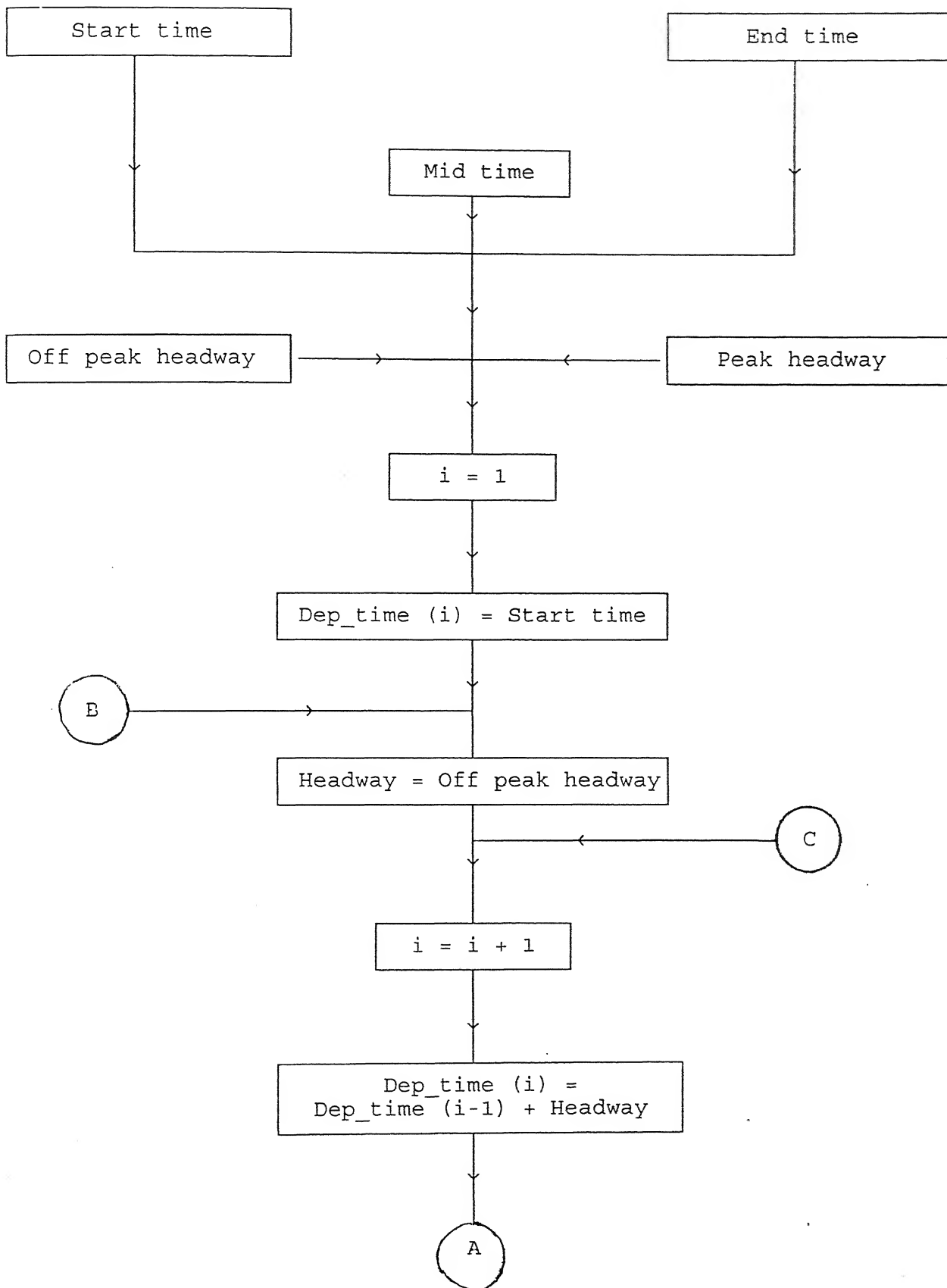
operation period, headway is not kept uniform. In the early morning and evening, demand being low, a larger headway is adopted which is known as off-peak headway. During day period when demand is high, a smaller headway, known as peak headway is used. Off peak headway is generally kept half of the peak headway.

(e) Rest time: As per the labour laws prevailing in the country, during the working of a crew, a rest time of 30 minutes at least is to be provided before completion of 5 hours of turn-on time. For the rest, a bus can be stored at an available terminal only according to the type of the route. In case of Type I route, a bus has to complete a round trip before rest or crew change and thus, the rest can be given only after even number of the single trips like trip 2, 4, 6 etc. Rest time should be even multiple of the headway subject to a minimum of 30 minutes. This rest time is exclusive of the lagover time.

(f) Crew change time: According to the labour laws, a set of crew can work only for a period of eight and half hours maximum, including the rest time. In a day, each bus is to be operated for two shifts, each of 8.5 hours.

As each bus is assumed to be operated by a separate operator, the operation should be such that all the operators on their respective routes, make identical number of trips during the operation period. For an efficient operation it is necessary that only one bus should run in a particular direction at a particular departure time.

In giving rest to the crew and in changing the crew, some



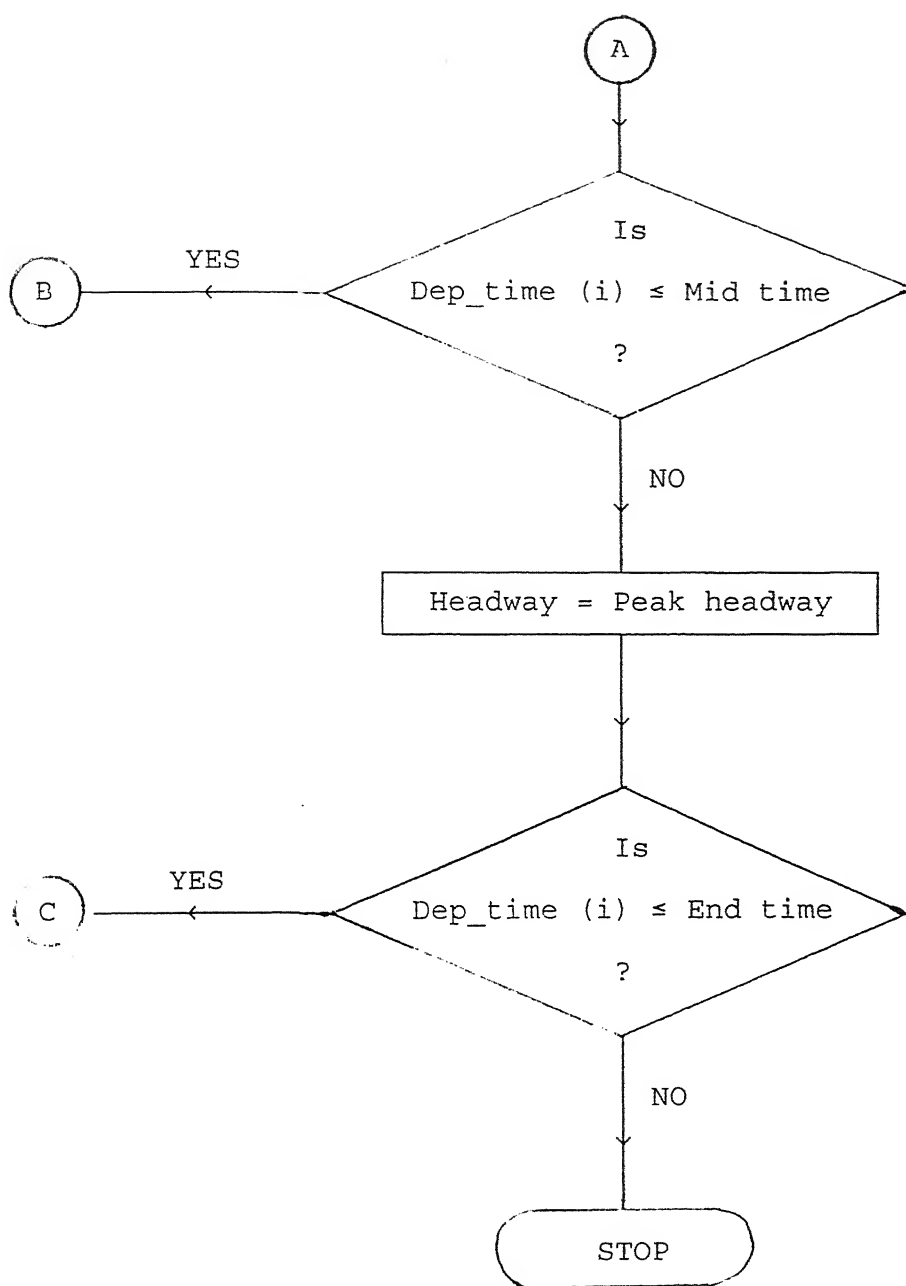


Fig. 3.1 GENERATION OF DEPARTURE TIMES AT THE TERMINALS

trips may be skipped. It depends on the rest time, layover time and headway.

3.2 PROGRAM LOGIC AND DEVELOPMENT

3.2.1 Generation of Departure Time at Terminals

From the given start time, mid time, end time and peak and off-peak headway, the possible departure times are generated at the terminals. Only these times are possible when a trip can originate. At both the terminals, the same departure times occurs and at a particular departure time two buses can run but in opposite directions i.e. from different terminals. Let the $Dep_time(i)$ be the departure time for the i th trip from a terminal, corresponding to the trip number. The procedure involves the following steps:

- (i) The first possible departure time is the start time i.e.

$$Dep_time(1) = \text{Start time}$$
- (ii) Increase the trip number i by one

$$i = i + 1$$
- (iii) Increase the Dep_time by Off peak headway

$$Dep_time(i) = Dep_time(i-1) + \text{Off peak headway}$$
- (iv) Repeat Step (ii) through (iii) until the mid time occurs.
- (v) Now increase the Dep_time by peak headway

$$Dep_time(i) = Dep_time(i-1) + \text{Peak headway}$$
- (vi) Repeat Step (v) until the End time occurs.

Figure 3.1 shows a flow chart of generation of departure times at the terminals.

3.2.2 Operational Characteristics of the Buses

- (a) Maximum number of unidirectional (single) trips before crew change is estimated as below:

Maximum trips before crew change

$$= \frac{\text{Crew change time (8.5 hours)}}{\text{Travel time} + \text{Layover time}}$$

It is rounded to a lower integer number.

- (b) Maximum number of single trips before the rest depends on the period before which the rest to the crew is to be given. This period is taken as 5 hours. This also depends on travel time and layover time.

Maximum trips before rest

$$= \frac{\text{Maximum rest period (5 hours)}}{\text{Travel time} + \text{Layover time}}$$

It is rounded to a lower integer number.

- (c) The number of trips which have to be skipped by each bus in providing the rest. This is estimated as below:

$$\text{Skipped trips} = \frac{\text{Rest time} - \text{Layover time}}{\text{Peak headway}}$$

It is rounded to a higher integer number.

Here peak headway is taken, as the off peak headway exists for a short duration (generally before 7.00 hours morning) and rest is given during the peak headway.

- (d) Maximum number of trips which are possible during the operation period irrespective of number of the buses deployed on the route are estimated as follows:

$$\begin{aligned} \text{Maximum total trips} &= \frac{\text{Mid time} - \text{Start time}}{\text{Offpeak headway}} \\ &+ \frac{\text{End time} - \text{Mid time}}{\text{Peak headway}} + 1 \end{aligned}$$

It is rounded to a lower integer number.

- (e) Maximum number of the trips which are possible to be made by each bus after skipping the necessary trips is estimated as below:

$$\text{Maximum trips per bus} =$$

$$\frac{\text{Maximum total trips}}{\text{Number of buses}} - \text{Skipped trips}$$

It is rounded to a lower integer number.

- (f) Sometimes it is not possible to run the buses completely for two shifts because of the constraint that all the buses are to make identical number of trips or due to the inconsistency between the headway and number of the buses. In such cases, first shift consists of the trips equal to the maximum trips before crew change but the second shift consists of lesser trips. Thus the effective total trips for each bus are estimated and this number is identical for all the buses. In doing so, sometimes the operation stops before the end time. This effective number of trips is taken equal to the maximum trips per bus or twice the maximum trips before crew change, whichever is smaller.

Figure 3.2 shows the flow chart of determination of effective maximum trips.

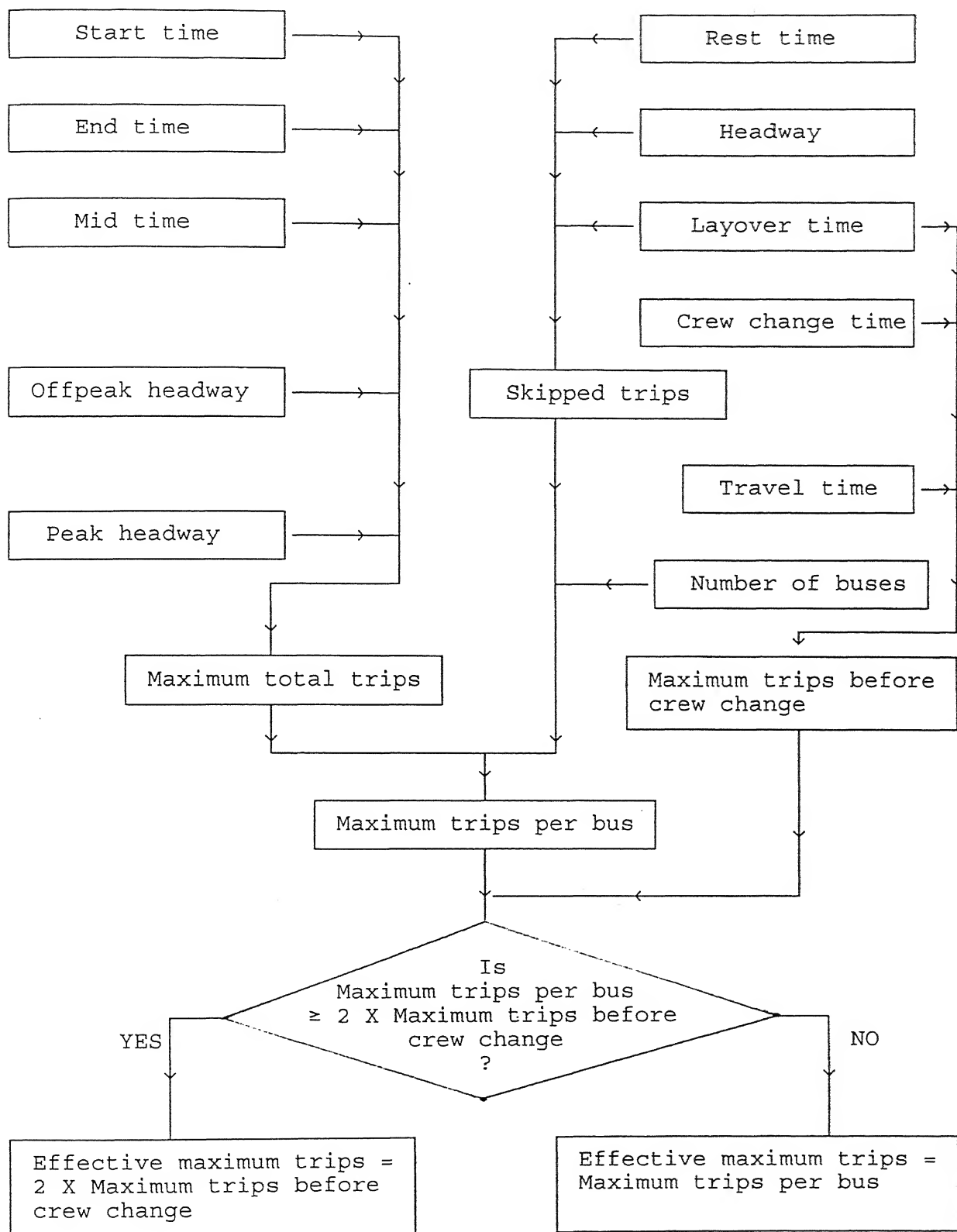


Fig. 3.2 DETERMINATION OF EFFECTIVE MAXIMUM TRIPS

3.2.3 Assignment of Buses to the Generated Departure Times

(A) The generated departure times at the terminals are arranged in ascending order. Each trip in the time table has the following parameters:

- (a) Trip serial number varying from 1 to total effective maximum trips by a bus.
 - (b) Departure time for each trip at the terminals.
 - (c) Direction of movement of the bus, for each trip. It is not required in case of Type I routes.
 - (d) Identification number of the bus assigned to distinguish it, varying from 1 to total number of buses deployed on a route.
- (B) Certain parameters are associated with each bus which are revised as the assignment progresses. These are as below:

- (a) Identification number of the bus. It varies from 1 to total number of buses deployed.
- (b) Serial number of the trip which the bus makes.
- (c) Direction of bus movement, which the bus is going to make for the current trip. Direction is denoted as 1, if the movement is from terminal-1 to terminal-2 and 2, if the movement is from terminal-2 to terminal-1.
- (d) Total number of the trips, which the bus has made yet.
- (e) Departure time of the bus for the current trip.
- (f) Departure time at which, the bus will be available to make the next trip. This is determined as below:

- (i) If total number of trips is not equal to the maximum trips before rest:

$$\begin{aligned} \text{Next time} &= \text{Current departure time} + \text{Travel time} \\ &\quad + \text{Layover time} \end{aligned}$$

(ii) If total number of trips is equal to the maximum trips before rest:

$$\begin{aligned}\text{Next time} &= \text{Current departure time} + \text{Travel time} \\ &+ \text{Layover time} + \text{Rest time}\end{aligned}$$

At the start, all the buses are assigned to only terminal-1 in case of Type I route and hence all the trips generate from that terminal. At the end of operation period, all the buses come back to terminal-1 and are stored there. In such a case, the direction of movement is not important, as at a particular departure time, only one bus can run in a direction and i.e. from terminal-1 to terminal-2. Thus each bus has to complete a round trip before being parked for the rest or during non-operation period.

In case of Type II route, half of the total buses deployed on the route, are stored at terminal-1 and remaining half at terminal-2. At the start, two buses run at a particular departure time but from the different terminals i.e. in opposite directions.

In case of Type III route, there is only one terminal which is used as both, origin as well as destination terminal. In such a case, however all the buses are stored at the same terminal but half of these are directed to move in clockwise direction (i.e. direction-1) and remaining half, in anticlockwise direction (i.e. direction-2). In this case, if a bus starts moving in clockwise direction then it retains this direction throughout the operation period.

(C) Stages for assignment of the buses: Assignment of the buses is done in following four stages:

Stage-I : From the start of morning shift to the rest period.

Stage II : From the end of rest to the period of crew change.

Stage III: From the start of second shift to the rest period.

Stage IV : From the end of the rest to the end of second shift or end time.

(D) Procedure for assignment of buses: The following procedure is adopted for assignment of the buses to their respective departure times. In case of Type II and Type III routes, it is assumed that the buses having odd identification number (Id-No.), start movement in direction-1 and those having even Id-No., start movement in direction-2, initially.

STEPS:

- (i) Start with bus Id-No. k ; ($k = 1$ at start) and proceed as below for k^{th} bus.
- (ii) Start from Dep_time [i]; ($i = 1$ at start).
- (iii) Check if Dep_time [i] is used by a bus of lower Id-No. in the same direction (by comparing the Dep_time [i] to the elements of array Timeused [j] given in Step (vii) and also that Dep_time [i] is less than next_time of k^{th} bus?
 if yes
 $i = i + 1$ and go to Step (ii)
 else continue.
- (iv) Increase the number of trips made by the k^{th} bus by unity.
- (v) Check, if
 (no. of trips made by k^{th} bus)
 = Maximum trips before rest?
 if yes
 Dep_time of k^{th} bus = Dep_time [i] + Rest time

Next_time of k^{th} bus = Dep_time [i] + Rest time
 + Travel time + Layover time

if no

Dep_time of k^{th} bus = Dep_time [i]

Next_time of k^{th} bus = Dep_time [i] + Travel time
 + Layover time

(vi) Direction of k^{th} bus = 1, if movement is from terminal-1
 to terminal-2, and
 = 2, if movement is from terminal-2
 to terminal-1.

(vii) Place the Dep_time of k^{th} bus and direction, in an array
 Timeused [j].

(viii) If (no. of trips made by k^{th} bus)
 = Maximum trips before crew change
 then "CHANGE THE CREW"
 else continue.

(ix) If (no. of trips made by k^{th} bus)
 ≤ Effective maximum trips
 then

i = i + 1, go to Step (ii)

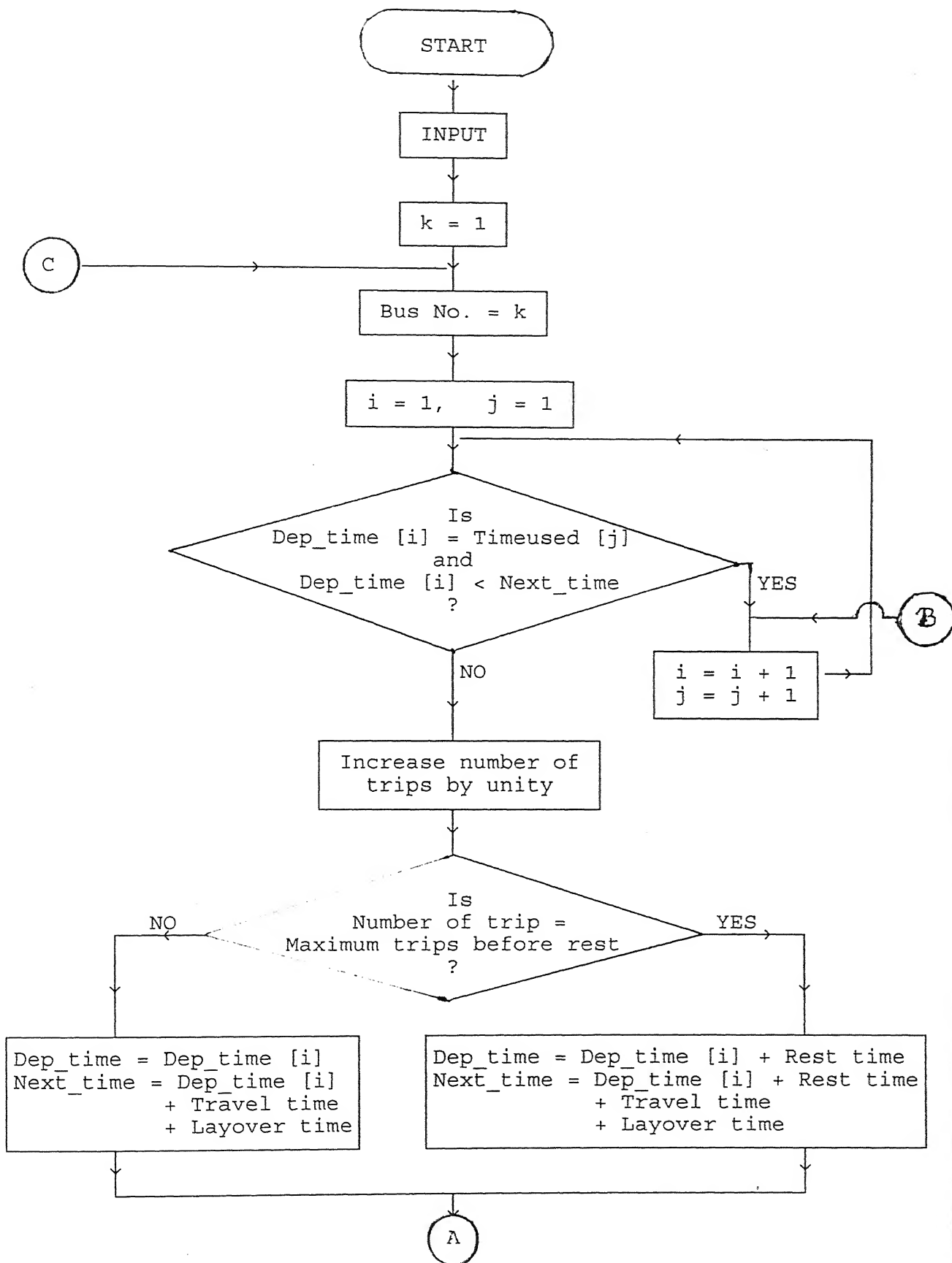
else continue.

(x) k = k + 1;

if k ≤ Number of buses deployed on the route
 then go to the Step (i)
 else continue.

(xi) STOP.

A flow chart (Figure 3.3) shows the whole procedure of assignment.



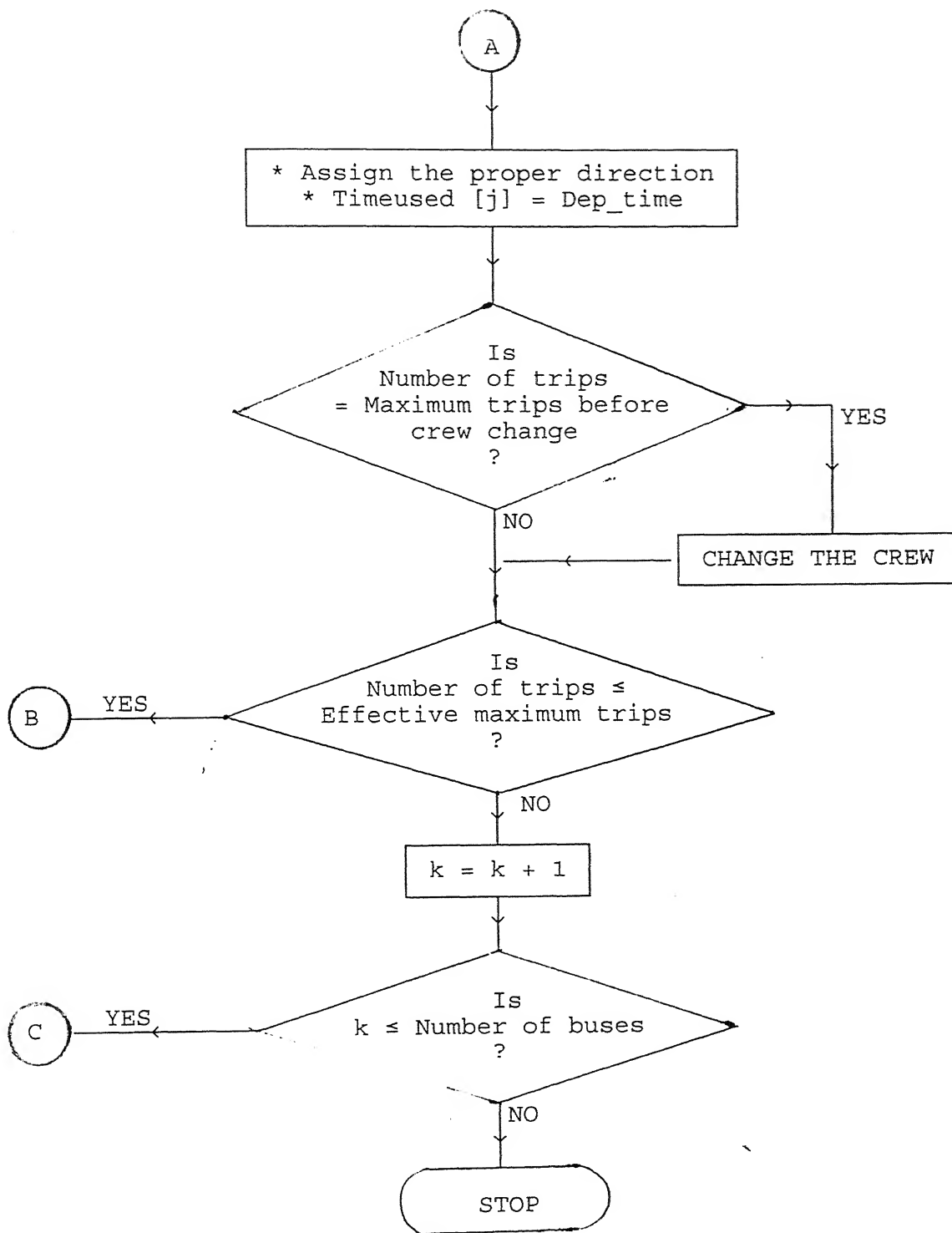


Fig. 3.3 PROCEDURE OF ASSIGNMENT OF BUSES TO DEPARTURE TIMES

3.2.4 Output of the Program

3.2.4.1 Output in Tabular Form:

Output of the program in tabular form shows the following parameters:

- I. Departure times of each bus on the terminals.
- II. Direction of the bus movement: It is not considered in Type I route, as all the buses originate from one terminal only and hence they will have the same direction at their departure from that terminal. In case of Type II and Type III routes, direction of each bus at its departure times is required, as at the same departure time, two buses, one from each terminal, originate.
- III. Total number of trips made by each bus as well as the number of trips before crew change are also displayed.

3.2.4.2 Graphic Simulation Model:

In addition to the display of the time table in tabular form, the program also presents graphically the movement of the buses at their respective departure times at the terminals. In this graphic simulation model, different buses are represented by different colours. On the X-axis of the graphic screen, departure times are displayed at both the terminals. A colour line which represents a particular bus, moves from the departure time of the respective bus at one terminal, to its departure time at the other terminal and continues so upto its time to stop at the end of the operation period. This also shows the time taken in rest movements of all the buses are shown similarly by different colour lines. The complete procedure of the model development in a broad view is shown by a flow chart shown in Figure 3.4.

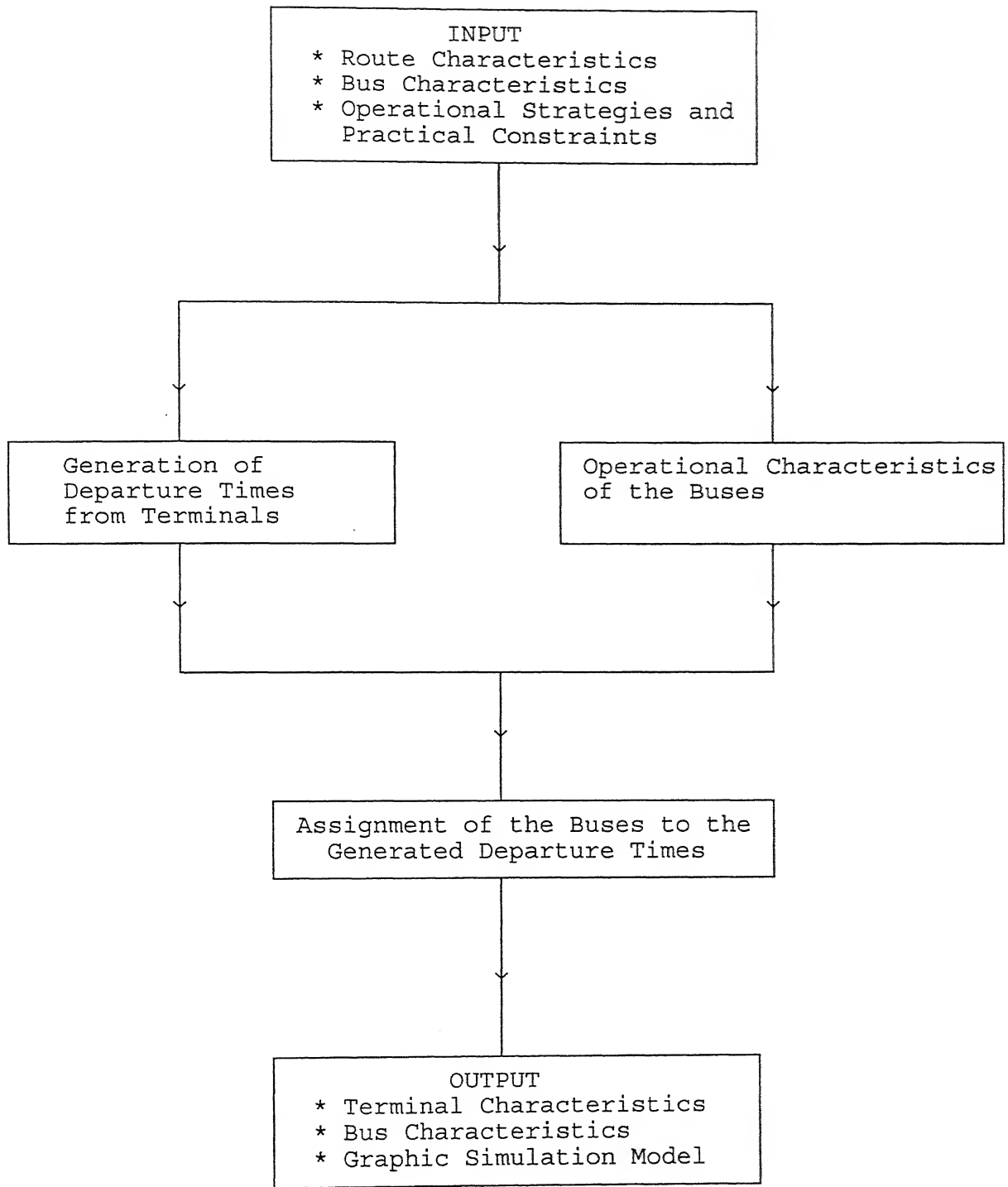


Fig. 3.4 MODEL DEVELOPMENT IN BROAD VIEW

4. PROGRAM WORKING AND APPLICATION

4.1 PACKAGE ILLUSTRATION

'TRANSTAB' is an interactive graphic package for preparing an efficient and rational time table for a bus transit network. The graphic capabilities of the package may be practically very useful for the users. This consists of three sets of programs, which are following:

1. Program for Type I routes
2. Program for Type II routes
3. Program for Type III routes

The program has been written in 'C' language on UNIX platform. Starbase Graphics Library of HP-UX System has been used for Graphic Simulation Model.

The package allows the user to have the following options:

1. To see the Time Table on the screen
 - (a) To give input from the keyboardOR (b) To give input from an input file.
2. To get the output in an output file
 - (a) To give input from the keyboardOR (b) To give input from an input file

The package separately shows the graphic display of movement of the buses for each route of the network.

All the program files and input files are stored in the same directory. This directory is "/home/user/timetab".

4.2 INPUT FOR THE PROGRAM

Input data required for preparation of Time Table are discussed in detail in Sec. 3.1.2. Some of these input data are fixed and are applicable to each route. These are rest period before which rest is to be given to the crew, crew change time and rest time which is to be consumed in taking rest. Rest period is taken as 5 hours from the start time. Crew change time is taken as 8.5 hours from the start time, including the rest time. Rest time is generally taken as minimum 30 minutes.

The data which may vary for different routes are fed into the program, either from the keyboard or from an input file as desired. These are listed below:

1. Route Number
2. Type of the Route
3. Start time (in hours)
4. End time (in hours)
5. Mid time (in hours)
6. Layover time (in minutes)
7. Peak headway (in minutes)
8. Travel time (in minutes)
9. Number of Buses

4.3 EXECUTION OF THE PROGRAM

To start the execution, first the relevant directory is opened. This directory is "/home/user/timetab". This has all the program files and input files. At the prompt, 'TAB' is typed to execute the program. The program first welcomes the user to

'TRANSTAB' (Figure 4.1), and holds the screen for 3 seconds. The next screen provides a menu containing two options:

1. OUTPUT ON SCREEN
2. OUTPUT IN A FILE

As per the desire, one of the option may be chosen. Option-1 is chosen to see the time table in tabular form on the screen directly from the execution. One screen shows the time table for one bus. Each screen has the message "PRESS RETURN TO CONTINUE" and "CTRL-C TO EXIT". Option-2 is chosen if the user wants to store the output in a file and later to see the contents under the editor command or 'cat' command. This is also opted when a print of the Time Table is needed.

After choosing an option, the next screen shows another menu which has following two options:

- (a) INPUT FROM KEYBOARD
- (b) INPUT FROM FILE

The user can choose option (a) if the data are to be given from the keyboard. The package, being user friendly guides the user to enter the proper input data. If the data are to be given from the input file, option (b) is chosen. This input file must be in the same directory. To help the user to see the name of input file, all the files stored in the directory are displayed. The proper file name is chosen and typed. If filename is typed wrongly, the program gives another chance with error message. Each screen has option to proceed or to exit as desired.

4.4 EXECUTION OF GRAPHIC SIMULATION MODEL

The graphic simulation model program is run on a HP Workstation, as it uses Starbase Graphics Library. This program named as "TIMEPLOT" uses the output of "TRANSTAB" and plots the movement of each bus on a route, representing the different bus by different colour. This shows both the terminals with generated departure times. This program takes the input from a file.

To execute the graphic program, 'PLOT' is typed at the prompt. The program shows the plot of movement of one bus on one screen. The screen has the message to proceed or exit. Press 'RETURN' to see the plot of next bus and it is continued until all the buses are shown. After that the program shows the movements of all buses deployed on the route on one screen only.

4.5 OUTPUT OF THE PROGRAM

The contents of output of the program are discussed in detail in Sec. 3.2.4. Here is a list of the parameters which are displayed on the screen for each route:

1. Route Number
2. Type of the Route
3. Total Number of Trips by each Bus
4. Departure Times and Direction of each Bus
5. Crew Change Time

The graphic display shows the movement of the busses on the screen with different colours. The complete execution for a route of Type I (Route No. 4), is shown through the Figures 4.1 to 4.10.

WELCOME TO TRANSTAB

Fig. 4.1 WELCOME SCREEN

ENTER OPTION !
OUTPUT ON SCREEN : 1
OUTPUT IN FILE : 2
2
ENTER OUTPUT FILE NAME !
P4.OUT

PRESS RETURN TO CONTINUE CTRL-C TO EXIT

Fig. 4.2 OUTPUT OPTION SCREEN

ENTER OPTION !

INPUT FROM KEYBOARD : K
INPUT FROM FILE : F
F

PRESS RETURN TO CONTINUE

CTRL-C TO EXIT

Fig. 4.3 INPUT OPTION SCREEN

```
ENTER INPUT FILE NAME !
r4.input
FILE DOES NOT EXIST ! FILES IN THE DIRECTORY ARE:
plot      r2.inp      tab      tab2.c
plot.c    r4.inp      tab.c     tab3.c
r1.inp    r6.inp      tab1.c    time.c

ENTER AGAIN !
r4.inp
OUTPUT IN r4.out
```

PRESS RETURN TO CONTINUE CTRL-C TO EXIT

Fig. 4.4 'ERROR MESSAGE AND DISPLAY OF FILES IN DIRECTORY' SCREEN

ROUTE # : 4 KRISHNA NAGAR TO KESHAV PURAM B-2
 ROUTE TYPE : 1 NO. OF BUSES: 4
 NO. OF ROUND TRIPS BY EACH BUS : 6
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 3

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		
1	05.00	06.16
2	07.48	09.04
3	11.00	12.16
	CREW	CHANGE
4	14.12	15.28
5	17.24	18.40
6	20.36	21.52

BUS # 2		

7	05.48	07.04
8	08.36	09.52
9	11.48	13.04
	CREW	CHANGE
10	15.00	16.16
11	18.12	19.28
12	21.24	22.40

BUS # 3		

13	06.36	07.52
14	09.24	10.40
15	12.36	13.52
	CREW	CHANGE
16	15.48	17.04
17	19.00	20.16
18	22.12	23.28

BUS # 4		

19	07.24	08.40
20	10.12	11.28
21	13.24	14.40
	CREW	CHANGE
22	16.36	17.52
23	19.48	21.04
24	23.00	00.16

Fig. 4.5 'OUTPUT OF THE PROGRAM' SCREEN

ROUTE NO. 4 : KRISHNA NAGAR TO KESHAV PURAM B-2

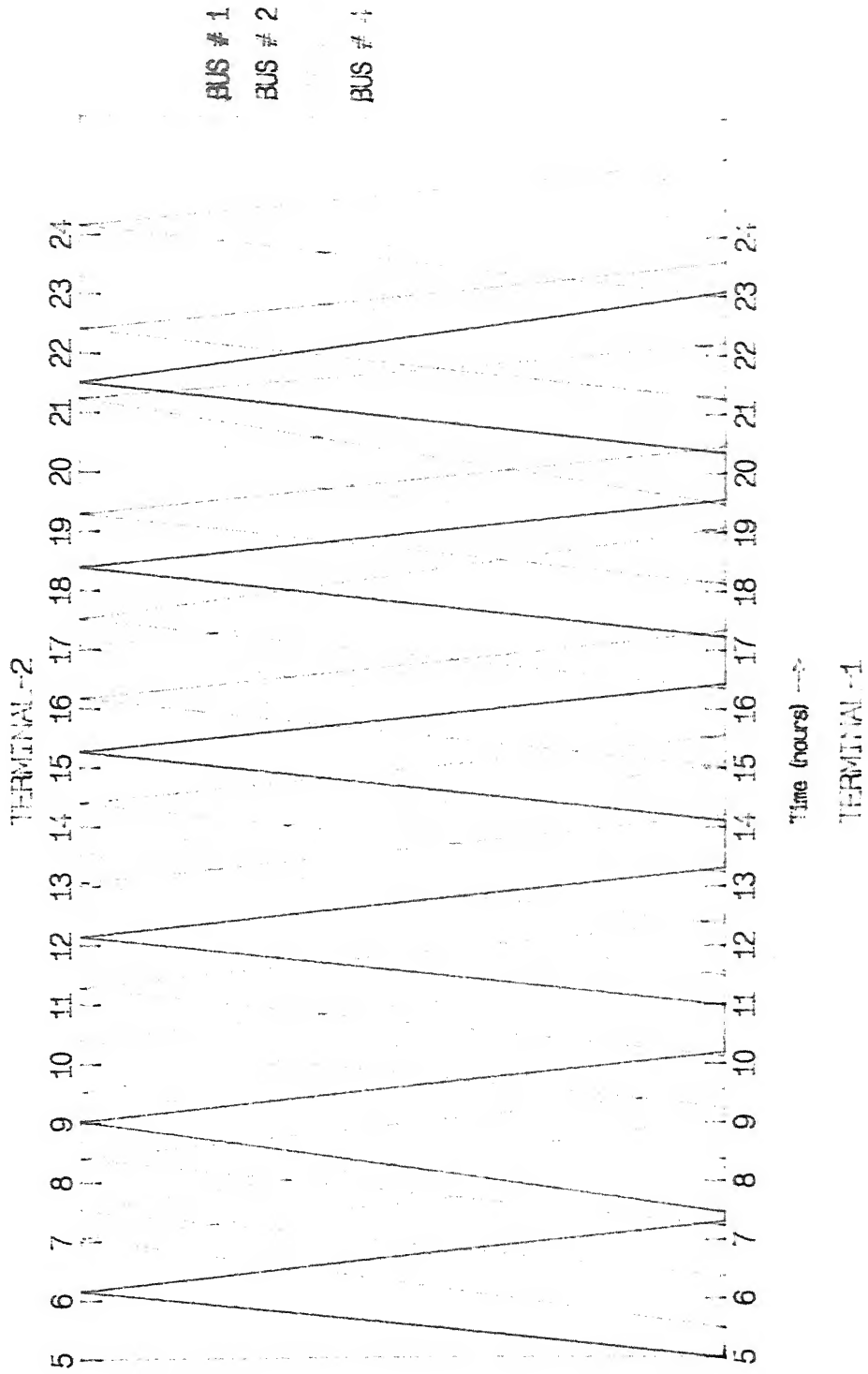


Fig. 4.6 GRAPHIC DISPLAY OF MOVEMENT OF BUSES

ROUTE NO. 4 : KRISHNA NAGAR TO KESHAV PURAM B-2

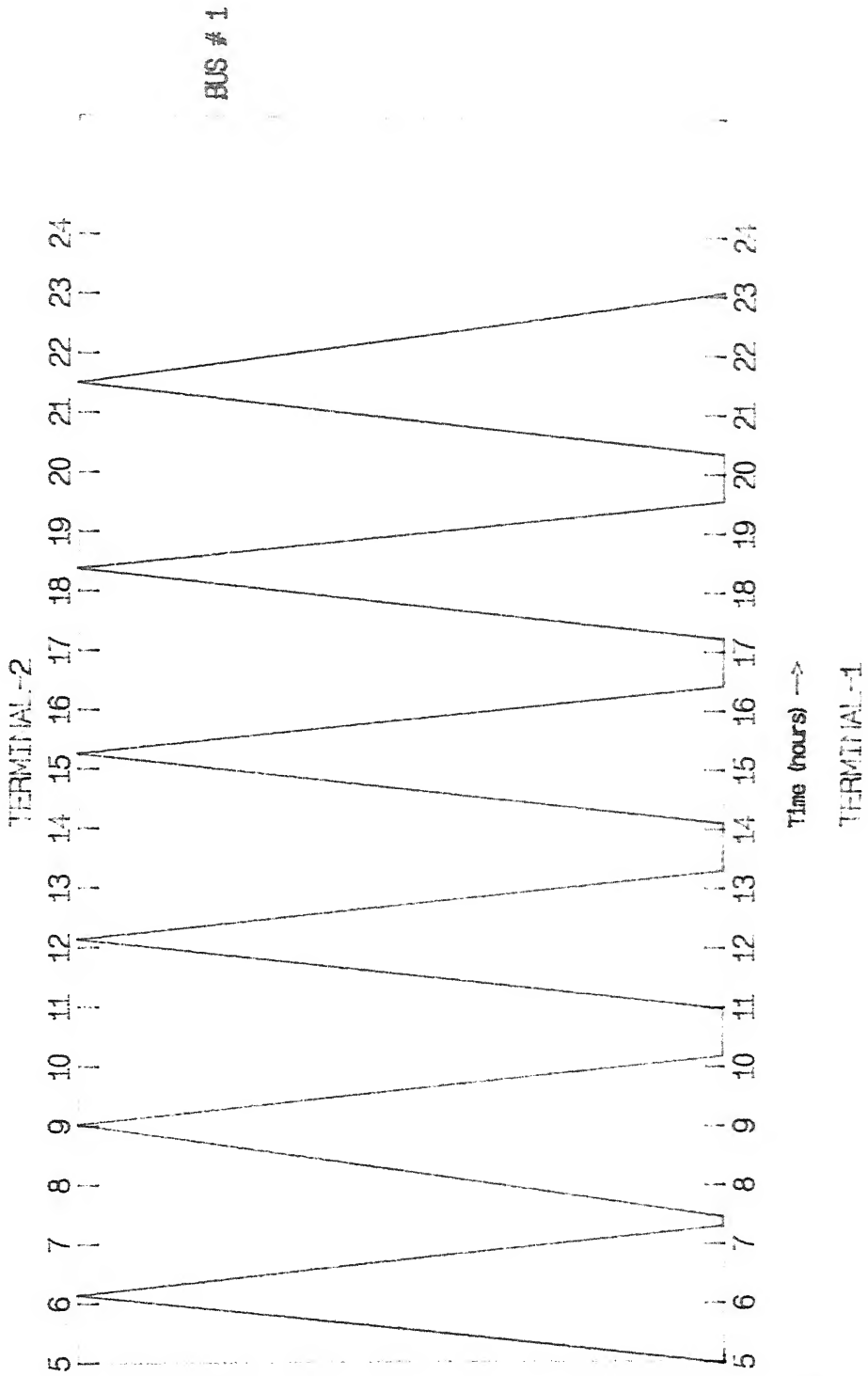


Fig. 4.7 GRAPHIC DISPLAY FOR BUS NO. 1

ROUTE NO. 4 : KRISHNA NAGAR TO KESHAV PURAM B-2

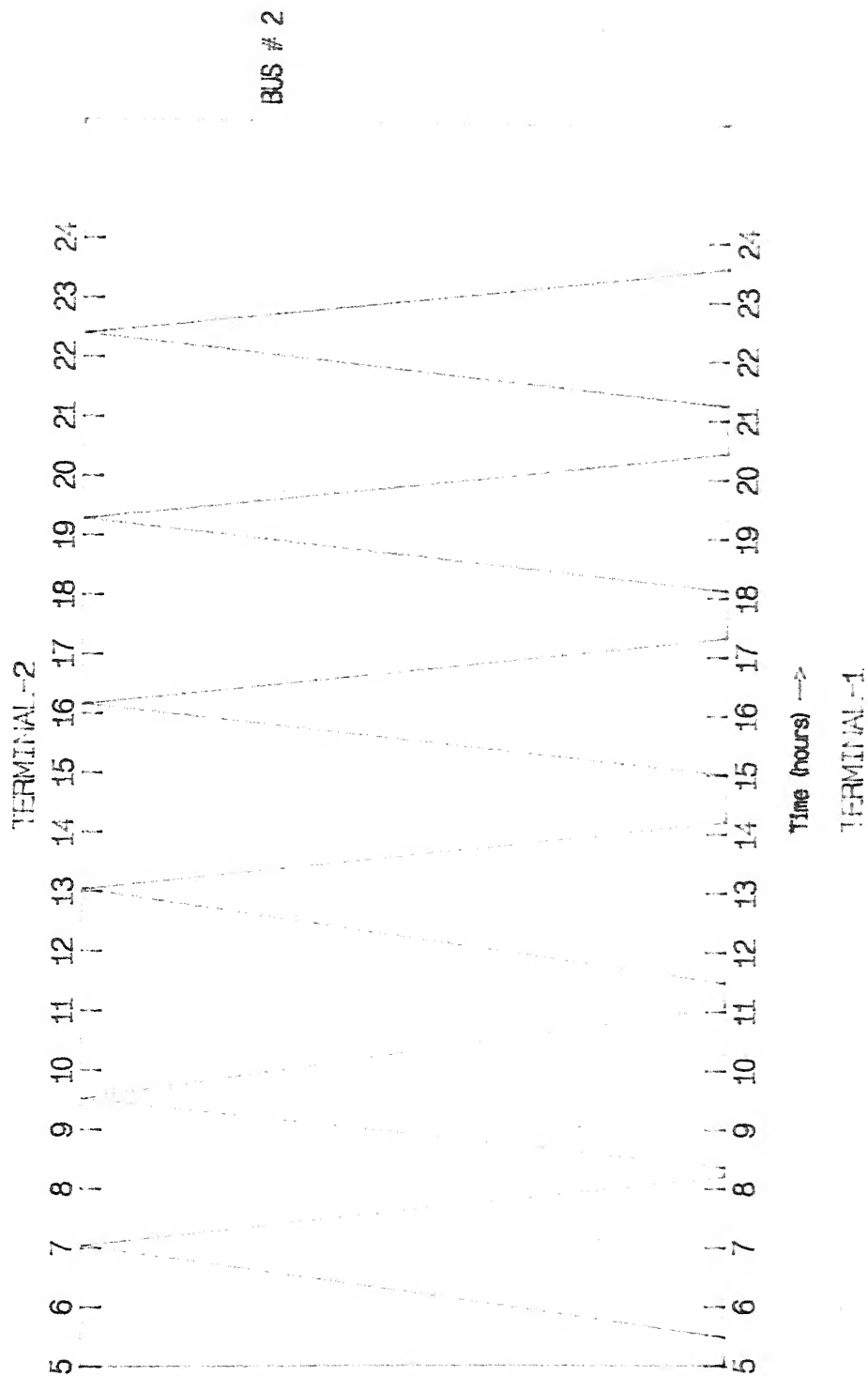


Fig. 4.8 GRAPHIC DISPLAY FOR BUS NO. 2

ROUTE NO. 4 : KRISHNA NAGAR TO KESHAV PURAM B-2

TERMINAL -2

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Time (hours) →

TERMINAL -1

5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

Fig. 4.9 GRAPHIC DISPLAY FOR BUS NO. 3

ROUTE NO. 4 : KRISHNA NAGAR TO KESHAV PURAM B-2

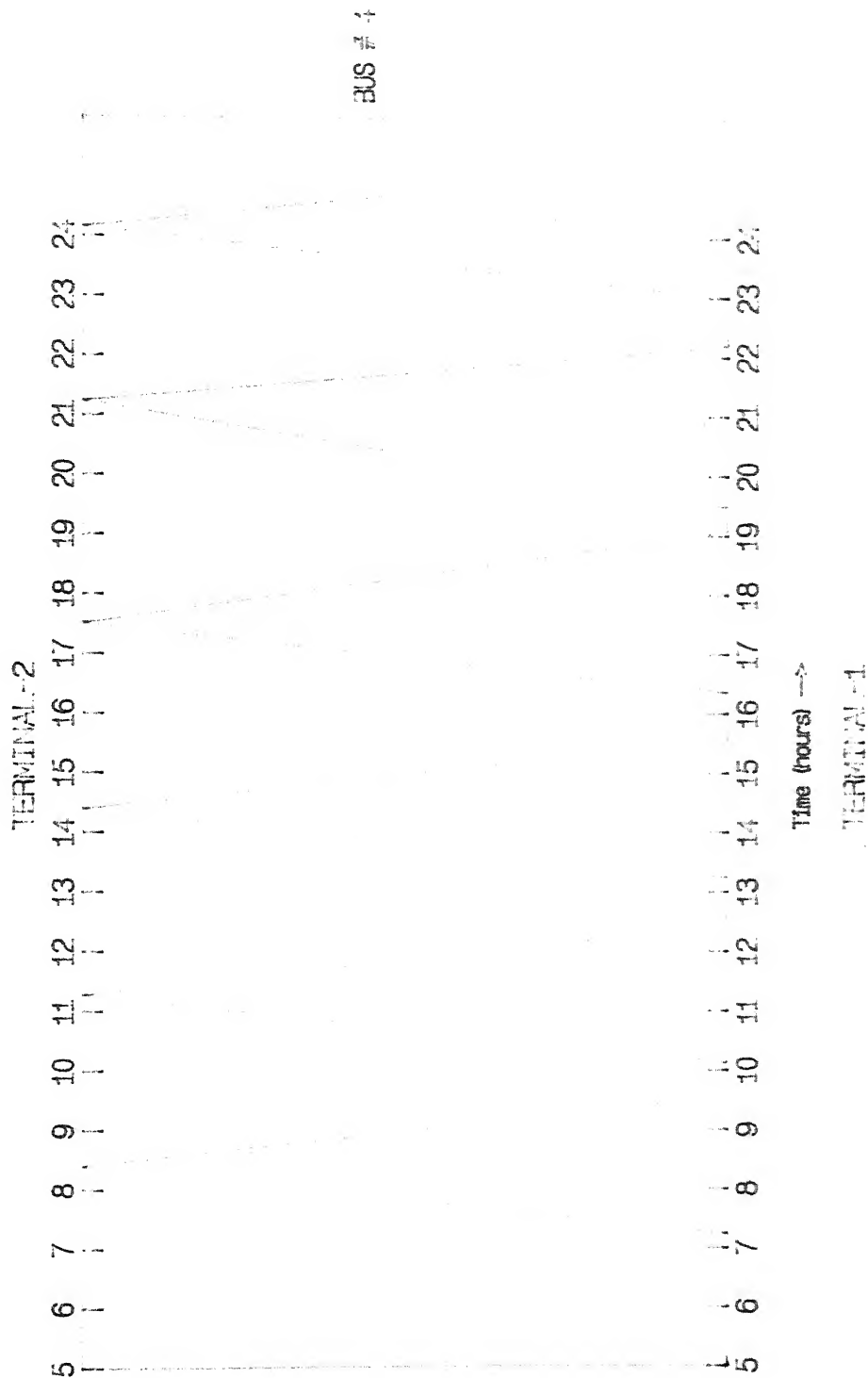


Fig. 4.10 GRAPHIC DISPLAY FOR BUS NO. 4

4.6 APPLICATION TO SOME ROUTES OF DELHI

The program has been applied to 30 routes of Delhi Metropolitan area to test the rationality and generality of the package. Input data collected by secondary sources, are fed into the program and results are analyzed. The Time Table for each route is found quite logical and it satisfies all the practical and operational constraints related to the route characteristics and labour laws. Input data and other descriptive parameters of these 30 routes are presented in Table 4.1. The Time Table for each of these 30 routes is shown in tabular form (Table 4.2 to 4.31).

TABLE 4.1 : INPUT DATA AND DESCRIPTIVE PARAMETERS FOR THE ROUTES

Route Number	Name of the Route	Route Type	Start time (Hours & Minutes)	End time (Hours & Minutes)	Mid time (Hours & Minutes)	Layover time (Minutes)	Headway (Minutes)	Travel time (Minutes)	Number of Buses
1	Madanpur Khadar To Minto Road	2	5.00	21.30	7.24	6	24	70	6
2	Sarita Vihar To Minto Road	2	5.12	21.36	7.20	6	12	75	6
3	Shahadara To Shahadara	3	5.00	21.30	7.24	6	24	70	6
4	Krishna Nagar To Keshav Puram B-2	1	5.00	23.30	7.24	6	24	70	4
5	Shahadara To Lajpat Nagar	1	5.00	21.40	7.00	10	15	75	6
6	Chander Nagar To Chander Nagar	3	5.30	23.30	7.18	10	18	85	6
7	Chander Nagar To Rohini Sec-6	2	5.00	23.15	7.00	10	15	50	6
8	Geeta Colony To Rajendra Place	2	5.30	23.00	7.06	10	16	70	6
9	Kailash Nagar To Kailash Nagar	3	5.00	22.00	7.16	10	17	85	5
10	Seelampur To Seelampur	3	5.00	20.30	6.52	10	14	112	8
11	Babarpur Extn. To Rly. Station	1	5.00	22.30	7.00	5	20	50	4
12	Yamuna Vihar C-4 To Kauria Bridge	1	5.30	21.00	7.00	10	30	90	6
13	Begampur To Rly. Station	1	5.00	21.30	7.30	5	25	65	4
14	Rawata To Tilak Nagar	1	6.00	21.00	7.08	10	34	85	5
15	Vikramপুর H-3 To Hizamuddin Rly. Station	2	5.30	23.30	7.18	10	18	85	6
16	Mukhmelpur To ISBT	1	5.30	24.10	7.22	10	28	70	5
17	Nand Nagari To Rani Bagh/ Mahindra Park	1	5.00	22.00	6.52	10	28	60	5
18	Rani Bagh To Rani Bagh	3	5.00	23.15	7.00	10	15	50	6

Continued...

TABLE 4.1 (Continued)

Route Number	Name of the Route	Route Type	Start time (Hours & Minutes)	End time (Hours & Minutes)	Mid time (Hours & Minutes)	Layover time (Minutes)	Headway (Minutes)	Travel time (Minutes)	Number of Buses
19	Nazafgarh To Nizamuddin Rly. Station	2	5.00	23.30	7.16	10	17	85	6
20	Bindapur DDA Flats To Rly. Station	2	5.00	20.30	6.52	10	14	112	8
21	Mohan Garden To Minto Road	1	5.00	23.30	7.00	10	15	75	4
22	Mori Gate To Mori Gate	2	5.12	21.36	7.00	10	18	75	6
23	Nazafgarh To ISBT	1	5.00	23.15	7.00	10	15	50	6
24	Okhla to Okhla	3	5.30	23.00	7.06	10	16	70	6
25	Safdarjung (T) To Safdarjung (T)	3	5.00	23.30	7.16	10	17	85	6
26	Narela Mandi To Fatehpuri	1	5.30	21.30	7.00	10	30	105	5
27	Jheel To Dera Village	1	5.10	22.30	7.50	10	40	100	5
28	Tuglakabad Rly. Station To Old Delhi Rly. Station	1	6.05	20.00	7.09	5	32	90	5
29	Yamuna Vihar C-4 To R.K. Puram	1	5.00	22.00	6.52	10	28	60	5
30	Jharoda Kalan To C Sec.	1	6.00	21.00	7.00	10	30	90	6

TABLE 4.2 TIME TABLE FOR ROUTE NO.1

ROUTE # : 1 MADANPUR KHADAR TO MINTO ROAD			
ROUTE TYPE : 2		NO. OF BUSES :	6
NO. OF SINGLE TRIPS BY EACH BUS :			9
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			6

S_NO.	DEP.TIME AT ORIGIN TERM.	DIREC -TION	DEP.TIME AT DESTN.TERM.

BUS # 1			

1	05.00	1	06.16
2	06.36	2	07.52
3	08.12	1	09.28
4	10.18	2	11.34
5	11.48	1	13.04
6	13.24	2	14.40
	CREW	CHANGE	
7	15.30	1	16.46
8	17.00	2	18.16
9	18.36	1	19.52

BUS # 2			

10	05.00	2	06.16
11	06.36	1	07.52
12	08.12	2	09.28
13	10.18	1	11.34
14	11.48	2	13.04
15	13.24	1	14.40
	CREW	CHANGE	
16	15.30	2	16.46
17	17.00	1	18.16
18	18.36	2	19.52

BUS # 3			

19	05.48	1	07.04
20	07.24	2	08.40
21	09.00	1	10.16
22	11.06	2	12.22
23	12.36	1	13.52
24	14.12	2	15.28
	CREW	CHANGE	
25	16.18	1	17.34
26	17.48	2	19.04
27	19.24	1	20.40

Contd..

TABLE 4.3 TIME TABLE FOR ROUTE NO.2

ROUTE # : 2 SARITA VIHAR TO MINTO ROAD			
ROUTE TYPE : 2		NO. OF BUSES :	6
NO. OF SINGLE TRIPS BY EACH BUS :			10
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			6

S_NO.	DEP.TIME AT ORIGIN TERM.	DIREC -TION	DEP.TIME AT DESTN.TERM.

BUS # 1			

1	05.12	1	06.33
2	07.00	2	08.21
3	08.30	1	09.51
4	10.30	2	11.51
5	12.06	1	13.27
6	13.36	2	14.57
	CREW	CHANGE	
7	15.36	1	16.57
8	17.12	2	18.33
9	18.42	1	20.03
10	20.42	2	22.03

BUS # 2			

11	05.12	2	06.33
12	07.00	1	08.21
13	08.30	2	09.51
14	10.30	1	11.51
15	12.06	2	13.27
16	13.36	1	14.57
	CREW	CHANGE	
17	15.36	2	16.57
18	17.12	1	18.33
19	18.42	2	20.03
20	20.42	1	22.03

BUS # 3			

21	05.48	1	07.09
22	07.18	2	08.39
23	08.48	1	10.09
24	10.48	2	12.09
25	12.24	1	13.45
26	13.54	2	15.15
	CREW	CHANGE	
27	15.54	1	17.15
28	17.30	2	18.51
29	19.00	1	20.21
30	21.00	2	22.21

Contd..

TABLE 4.3 (Contd.)

BUS # 4

31	05.48	2	07.09
32	07.18	1	08.39
33	08.48	2	10.09
34	10.48	1	12.09
35	12.24	2	13.45
36	13.54	1	15.15
	CREW	CHANGE	
37	15.54	2	17.15
38	17.30	1	18.51
39	19.00	2	20.21
40	21.00	1	22.21

BUS # 5

41	06.24	1	07.45
42	07.54	2	09.15
43	09.24	1	10.45
44	11.24	2	12.45
45	13.00	1	14.21
46	14.30	2	15.51
	CREW	CHANGE	
47	16.30	1	17.51
48	18.06	2	19.27
49	19.36	1	20.57
50	21.36	2	22.57

BUS # 6

51	06.24	2	07.45
52	07.54	1	09.15
53	09.24	2	10.45
54	11.24	1	12.45
55	13.00	2	14.21
56	14.30	1	15.51
	CREW	CHANGE	
57	16.30	2	17.51
58	18.06	1	19.27
59	19.36	2	20.57
60	21.36	1	22.57

TABLE 4.4 TIME TABLE FOR ROUTE NO.3

ROUTE # : 3 SHAHADARA TO SHAHADARA			
ROUTE TYPE : 3		NO. OF BUSES :	6
NO. OF SINGLE TRIPS BY EACH BUS :			9
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			6

S_NO.	DEP.TIME AT THE TERM.	DIREC -TION	ARVL.TIME AT THE TERM.

BUS # 1			

1	05.00	1	06.16
2	06.36	1	07.52
3	08.12	1	09.28
4	10.18	1	11.34
5	11.48	1	13.04
6	13.24	1	14.40
	CREW	CHANGE	
7	15.30	1	16.46
8	17.00	1	18.16
9	18.36	1	19.52

BUS # 2			

10	05.00	2	06.16
11	06.36	2	07.52
12	08.12	2	09.28
13	10.18	2	11.34
14	11.48	2	13.04
15	13.24	2	14.40
	CREW	CHANGE	
16	15.30	2	16.46
17	17.00	2	18.16
18	18.36	2	19.52

BUS # 3			

19	05.48	1	07.04
20	07.24	1	08.40
21	09.00	1	10.16
22	11.06	1	12.22
23	12.36	1	13.52
24	14.12	1	15.28
	CREW	CHANGE	
25	16.18	1	17.34
26	17.48	1	19.04
27	19.24	1	20.40

Contd..

TABLE 4.4 (Contd.)

BUS # 4

28	05.48	2	07.04
29	07.24	2	08.40
30	09.00	2	10.16
31	11.06	2	12.22
32	12.36	2	13.52
33	14.12	2	15.28
	CREW	CHANGE	
34	16.18	2	17.34
35	17.48	2	19.04
36	19.24	2	20.40

BUS # 5

37	07.48	1	09.04
38	09.24	1	10.40
39	11.00	1	12.16
40	13.00	1	14.16
41	14.36	1	15.52
42	16.12	1	17.28
	CREW	CHANGE	
43	18.12	1	19.28
44	19.48	1	21.04
45	21.24	1	22.40

BUS # 6

46	07.48	2	09.04
47	09.24	2	10.40
48	11.00	2	12.16
49	13.00	2	14.16
50	14.36	2	15.52
51	16.12	2	17.28
	CREW	CHANGE	
52	18.12	2	19.28
53	19.48	2	21.04
54	21.24	2	22.40

TABLE 4.5 TIME TABLE FOR ROUTE NO.4

 ROUTE # : 4 KRISHNA NAGAR TO KESHAV PURAM B-2
 ROUTE TYPE : 1 NO. OF BUSES: 4
 NO. OF ROUND TRIPS BY EACH BUS : 6
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 3

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	05.00	06.16
2	07.48	09.04
3	11.00	12.16
	CREW	CHANGE
4	14.12	15.28
5	17.24	18.40
6	20.36	21.52

 BUS # 2

7	05.48	07.04
8	08.36	09.52
9	11.48	13.04
	CREW	CHANGE
10	15.00	16.16
11	18.12	19.28
12	21.24	22.40

 BUS # 3

13	06.36	07.52
14	09.24	10.40
15	12.36	13.52
	CREW	CHANGE
16	15.48	17.04
17	19.00	20.16
18	22.12	23.28

 BUS # 4

19	07.24	08.40
20	10.12	11.28
21	13.24	14.40
	CREW	CHANGE
22	16.36	17.52
23	19.48	21.04
24	23.00	00.16

TABLE 4.6 TIME TABLE FOR ROUTE NO.5

 ROUTE # : 5 SHAHADARA TO LAJPAT NAGAR
 ROUTE TYPE : 1 NO. OF BUSES : 6
 NO. OF ROUND TRIPS BY EACH BUS : 5
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 3

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		
1	05.00	06.25
2	08.30	09.55
3	12.00	13.25
	CREW	CHANGE
4	15.30	16.55
5	19.00	20.25

BUS # 2		

6	05.30	06.55
7	09.00	10.25
8	12.30	13.55
	CREW	CHANGE
9	16.00	17.25
10	19.30	20.55

BUS # 3		

11	06.00	07.25
12	09.30	10.55
13	13.00	14.25
	CREW	CHANGE
14	16.30	17.55
15	20.00	21.25

BUS # 4		

16	06.30	07.55
17	10.00	11.25
18	13.30	14.55
	CREW	CHANGE
19	17.00	18.25
20	20.30	21.55

BUS # 5		

21	07.00	08.25
22	10.30	11.55
23	14.00	15.25
	CREW	CHANGE
24	17.30	18.55
25	21.00	22.25

Contd..

TABLE 4.6 (Contd.)

BUS # 6

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*****
26          07.15          08.40
27          10.45          12.10
28          14.15          15.40
                CREW          CHANGE
29          17.45          19.10
30          21.15          22.40
-----
```

TABLE 4.7 (Contd.)

BUS # 4

31	06.06	2	07.41
32	07.54	2	09.29
33	09.42	2	11.17
34	12.00	2	13.35
35	13.36	2	15.11
	CREW		CHANGE
36	15.24	2	16.59
37	17.42	2	19.17
38	19.18	2	20.53
39	21.06	2	22.41
40	22.54	2	00.29

BUS # 5

41	06.42	1	08.17
42	08.30	1	10.05
43	10.18	1	11.53
44	12.36	1	14.11
45	14.12	1	15.47
	CREW		CHANGE
46	16.00	1	17.35
47	18.18	1	19.53
48	19.54	1	21.29
49	21.42	1	23.17
50	23.30	1	01.05

BUS # 6

51	06.42	2	08.17
52	08.30	2	10.05
53	10.18	2	11.53
54	12.36	2	14.11
55	14.12	2	15.47
	CREW		CHANGE
56	16.00	2	17.35
57	18.18	2	19.53
58	19.54	2	21.29
59	21.42	2	23.17
60	23.30	2	01.05

TABLE 4.8 TIME TABLE FOR ROUTE NO.7

ROUTE # : 7 CHANDER NAGAR TO ROHINI SEC-6			
ROUTE TYPE : 2		NO. OF BUSES :	6
NO. OF SINGLE TRIPS BY EACH BUS :			16
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			8

S_NO.	DEP.TIME AT ORIGIN TERM.	DIREC -TION	DEP.TIME AT DESTN.TERM.

BUS # 1			

1	05.00	1	06.00
2	06.00	2	07.00
3	07.00	1	08.00
4	08.00	2	09.00
5	09.00	1	10.00
6	10.30	2	11.30
7	11.30	1	12.30
8	12.30	2	13.30
	CREW		CHANGE
9	13.30	1	14.30
10	14.30	2	15.30
11	16.00	1	17.00
12	17.00	2	18.00
13	18.00	1	19.00
14	19.00	2	20.00
15	20.00	1	21.00
16	21.00	2	22.00

BUS # 2			

17	05.00	2	06.00
18	06.00	1	07.00
19	07.00	2	08.00
20	08.00	1	09.00
21	09.00	2	10.00
22	10.30	1	11.30
23	11.30	2	12.30
24	12.30	1	13.30
	CREW		CHANGE
25	13.30	2	14.30
26	14.30	1	15.30
27	16.00	2	17.00
28	17.00	1	18.00
29	18.00	2	19.00
30	19.00	1	20.00
31	20.00	2	21.00
32	21.00	1	22.00

Contd..

TABLE 4.8 (contd.)

BUS # 3

33	05.30	1	06.30
34	06.30	2	07.30
35	07.30	1	08.30
36	08.30	2	09.30
37	09.30	1	10.30
38	11.00	2	12.00
39	12.00	1	13.00
40	13.00	2	14.00
	CREW		CHANGE
41	14.00	1	15.00
42	15.00	2	16.00
43	16.30	1	17.30
44	17.30	2	18.30
45	18.30	1	19.30
46	19.30	2	20.30
47	20.30	1	21.30
48	21.30	2	22.30

BUS # 4

49	05.30	2	06.30
50	06.30	1	07.30
51	07.30	2	08.30
52	08.30	1	09.30
53	09.30	2	10.30
54	11.00	1	12.00
55	12.00	2	13.00
56	13.00	1	14.00
	CREW		CHANGE
57	14.00	2	15.00
58	15.00	1	16.00
59	16.30	2	17.30
60	17.30	1	18.30
61	18.30	2	19.30
62	19.30	1	20.30
63	20.30	2	21.30
64	21.30	1	22.30

Contd..

TABLE 4.8 (contd.)

BUS # 5

65	07.15	1	08.15
66	08.15	2	09.15
67	09.15	1	10.15
68	10.15	2	11.15
69	11.15	1	12.15
70	12.45	2	13.45
71	13.45	1	14.45
72	14.45	2	15.45

CREW

CHANGE

73	15.45	1	16.45
74	16.45	2	17.45
75	18.15	1	19.15
76	19.15	2	20.15
77	20.15	1	21.15
78	21.15	2	22.15
79	22.15	1	23.15
80	23.15	2	00.15

BUS # 6

81	07.15	2	08.15
82	08.15	1	09.15
83	09.15	2	10.15
84	10.15	1	11.15
85	11.15	2	12.15
86	12.45	1	13.45
87	13.45	2	14.45
88	14.45	1	15.45

CREW

CHANGE

89	15.45	2	16.45
90	16.45	1	17.45
91	18.15	2	19.15
92	19.15	1	20.15
93	20.15	2	21.15
94	21.15	1	22.15
95	22.15	2	23.15
96	23.15	1	00.15

TABLE 4.9 TIME TABLE FOR ROUTE NO.8

ROUTE # : 8 GEETA COLONY TO RAJENDRA PLACE
 ROUTE TYPE : 2 NO. OF BUSES : 6
 NO. OF SINGLE TRIPS BY EACH BUS : 12
 NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE: 6

S_NO.	DEP.TIME AT ORIGIN TERM.	DIREC -TION	DEP.TIME AT DESTN.TERM.
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BUS # 1

1	05.30	1	06.50
2	07.06	2	08.26
3	08.26	1	09.46
4	10.16	2	11.36
5	11.38	1	12.58
6	12.58	2	14.18
CREW CHANGE			
7	14.48	1	16.08
8	16.10	2	17.30
9	17.30	1	18.50
10	19.20	2	20.40
11	20.42	1	22.02
12	22.02	2	23.22

BUS # 2

13	05.30	2	06.50
14	07.06	1	08.26
15	08.26	2	09.46
16	10.16	1	11.36
17	11.38	2	12.58
18	12.58	1	14.18
CREW CHANGE			
19	14.48	2	16.08
20	16.10	1	17.30
21	17.30	2	18.50
22	19.20	1	20.40
23	20.42	2	22.02
24	22.02	1	23.22

BUS # 3

25	06.02	1	07.22
26	07.22	2	08.42
27	08.42	1	10.02
28	10.32	2	11.52
29	11.54	1	13.14
30	13.14	2	14.34
CREW CHANGE			
31	15.04	1	16.24
32	16.26	2	17.46
33	17.46	1	19.06
34	19.36	2	20.56
35	20.58	1	22.18
36	22.18	2	23.38

Contd..

TABLE 4.9 (Contd.)

BUS # 4

37	06.02	2	07.22
38	07.22	1	08.42
39	08.42	2	10.02
40	10.32	1	11.52
41	11.54	2	13.14
42	13.14	1	14.34
	CREW		CHANGE
43	15.04	2	16.24
44	16.26	1	17.46
45	17.46	2	19.06
46	19.36	1	20.56
47	20.58	2	22.18
48	22.18	1	23.38

BUS # 5

49	06.34	1	07.54
50	07.54	2	09.14
51	09.14	1	10.34
52	11.04	2	12.24
53	12.26	1	13.46
54	13.46	2	15.06
	CREW		CHANGE
55	15.36	1	16.56
56	16.58	2	18.18
57	18.18	1	19.38
58	20.08	2	21.28
59	21.30	1	22.50
60	22.50	2	00.10

BUS # 6

61	06.34	2	07.54
62	07.54	1	09.14
63	09.14	2	10.34
64	11.04	1	12.24
65	12.26	2	13.46
66	13.46	1	15.06
	CREW		CHANGE
67	15.36	2	16.56
68	16.58	1	18.18
69	18.18	2	19.38
70	20.08	1	21.28
71	21.30	2	22.50
72	22.50	1	00.10

TABLE 4.10 TIME TABLE FOR ROUTE NO.9

ROUTE # : 9 KAILASH NAGAR TO KAILASH NAGAR			
ROUTE TYPE : 3		NO. OF BUSES :	5
NO. OF SINGLE TRIPS BY EACH BUS :			10
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			5

S_NO.	DEP.TIME AT THE TERM.	DIREC -TION	ARVL.TIME AT THE TERM.

BUS # 1			

1	05.00	1	06.35
2	06.42	1	08.17
3	08.24	1	09.59
4	10.36	1	12.11
5	12.22	1	13.57
	CREW		CHANGE
6	14.04	1	15.39
7	16.16	1	17.51
8	18.02	1	19.37
9	19.44	1	21.19
10	21.26	1	23.01

BUS # 2			

11	05.00	2	06.35
12	06.42	2	08.17
13	08.24	2	09.59
14	10.36	2	12.11
15	12.22	2	13.57
	CREW		CHANGE
16	14.04	2	15.39
17	16.16	2	17.51
18	18.02	2	19.37
19	19.44	2	21.19
20	21.26	2	23.01

BUS # 3			

21	05.34	1	07.09
22	07.16	1	08.51
23	08.58	1	10.33
24	11.10	1	12.45
25	12.56	1	14.31
	CREW		CHANGE
26	14.38	1	16.13
27	16.50	1	18.25
28	18.36	1	20.11
29	20.18	1	21.53
30	22.00	1	23.35

Contd..

TABLE 4.10 (Contd.)

BUS # 4

31	05.34	2	07.09
32	07.16	2	08.51
33	08.58	2	10.33
34	11.10	2	12.45
35	12.56	2	14.31

CREW

CHANGE

36	14.38	2	16.13
37	16.50	2	18.25
38	18.36	2	20.11
39	20.18	2	21.53
40	22.00	2	23.35

BUS # 5

41	06.08	1	07.43
42	07.50	1	09.25
43	09.32	1	11.07
44	11.44	1	13.19
45	13.30	1	15.05

CREW

CHANGE

46	15.12	1	16.47
47	17.24	1	18.59
48	19.10	1	20.45
49	20.52	1	22.27
50	22.34	1	00.09

TABLE 4.11 TIME TABLE FOR ROUTE NO.10

ROUTE # : 10 SEELAMPUR TO SEELAMPUR			
ROUTE TYPE : 3		NO. OF BUSES :	8
NO. OF SINGLE TRIPS BY EACH BUS :			7
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			4

S_NO.	DEP.TIME AT THE TERM.	DIREC -TION	ARVL.TIME AT THE TERM.

BUS # 1			

1	05.00	1	07.02
2	07.06	1	09.08
3	09.42	1	11.44
4	11.46	1	13.48
	CREW	CHANGE	
5	14.22	1	16.24
6	16.26	1	18.28
7	19.02	1	21.04

BUS # 2			

8	05.00	2	07.02
9	07.06	2	09.08
10	09.42	2	11.44
11	11.46	2	13.48
	CREW	CHANGE	
12	14.22	2	16.24
13	16.26	2	18.28
14	19.02	2	21.04

BUS # 3			

15	05.28	1	07.30
16	07.34	1	09.36
17	10.10	1	12.12
18	12.14	1	14.16
	CREW	CHANGE	
19	14.50	1	16.52
20	16.54	1	18.56
21	19.30	1	21.32

BUS # 4			

22	05.28	2	07.30
23	07.34	2	09.36
24	10.10	2	12.12
25	12.14	2	14.16
	CREW	CHANGE	
26	14.50	2	16.52
27	16.54	2	18.56
28	19.30	2	21.32

Contd..

TABLE 4.11 (Contd.)

BUS # 5

29	05.56	1	07.58
30	08.02	1	10.04
31	10.38	1	12.40
32	12.42	1	14.44
	CREW	CHANGE	
33	15.18	1	17.20
34	17.22	1	19.24
35	19.58	1	22.00

BUS # 6

36	05.56	2	07.58
37	08.02	2	10.04
38	10.38	2	12.40
39	12.42	2	14.44
	CREW	CHANGE	
40	15.18	2	17.20
41	17.22	2	19.24
42	19.58	2	22.00

BUS # 7

43	06.24	1	08.26
44	08.30	1	10.32
45	11.06	1	13.08
46	13.10	1	15.12
	CREW	CHANGE	
47	15.46	1	17.48
48	17.50	1	19.52
49	20.26	1	22.28

BUS # 8

50	06.24	2	08.26
51	08.30	2	10.32
52	11.06	2	13.08
53	13.10	2	15.12
	CREW	CHANGE	
54	15.46	2	17.48
55	17.50	2	19.52
56	20.26	2	22.28

TABLE 4.12 TIME TABLE FOR ROUTE NO.11

ROUTE # : 11 BABARPUR EXTN. TO RLY. STATION
 ROUTE TYPE : 1 NO. OF BUSES : 4
 NO. OF ROUND TRIPS BY EACH BUS : 8
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 4

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		
1	05.00	05.55
2	07.00	07.55
3	09.30	10.25
4	11.20	12.15
	CREW	CHANGE
5	13.50	14.45
6	15.40	16.35
7	18.10	19.05
8	20.00	20.55

BUS # 2		

9	05.40	06.35
10	07.40	08.35
11	10.10	11.05
12	12.00	12.55
	CREW	CHANGE
13	14.30	15.25
14	16.20	17.15
15	18.50	19.45
16	20.40	21.35

BUS # 3		

17	06.20	07.15
18	08.20	09.15
19	10.50	11.45
20	12.40	13.35
	CREW	CHANGE
21	15.10	16.05
22	17.00	17.55
23	19.30	20.25
24	21.20	22.15

BUS # 4		

25	07.20	08.15
26	09.20	10.15
27	11.40	12.35
28	13.40	14.35
	CREW	CHANGE
29	16.00	16.55
30	18.00	18.55
31	20.20	21.15
32	22.20	23.15

TABLE 4.13 TIME TABLE FOR ROUTE NO.12

ROUTE # : 12 YAMUNA VIHAR C-4 TO KAURIA BRIDGE
 ROUTE TYPE : 1 NO. OF BUSES : 6
 NO. OF ROUND TRIPS BY EACH BUS : 4
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 2

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		
1	05.30	07.10
2	09.30	11.10
	CREW	CHANGE
3	13.30	15.10
4	17.00	18.40

BUS # 2		

5	07.00	08.40
6	11.00	12.40
	CREW	CHANGE
7	15.00	16.40
8	18.30	20.10

BUS # 3		

9	07.30	09.10
10	11.30	13.10
	CREW	CHANGE
11	15.30	17.10
12	19.00	20.40

BUS # 4		

13	08.00	09.40
14	12.00	13.40
	CREW	CHANGE
15	16.00	17.40
16	19.30	21.10

BUS # 5		

17	08.30	10.10
18	12.30	14.10
	CREW	CHANGE
19	16.30	18.10
20	20.00	21.40

BUS # 6		

21	09.00	10.40
22	13.00	14.40
	CREW	CHANGE
23	17.00	18.40
24	20.30	22.10

TABLE 4.14 TIME TABLE FOR ROUTE NO.13

ROUTE # : 13 BEGAMPUR TO RLY. STATION		
ROUTE TYPE : 1	NO. OF BUSES :	4
NO. OF ROUND TRIPS BY EACH BUS :		6
NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE:		3

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	05.00	06.10
2	07.30	08.40
3	10.30	11.40
	CREW	CHANGE
4	12.55	14.05
5	15.55	17.05
6	18.20	19.30

BUS # 2		

7	05.50	07.00
8	08.20	09.30
9	11.20	12.30
	CREW	CHANGE
10	13.45	14.55
11	16.45	17.55
12	19.10	20.20

BUS # 3		

13	06.40	07.50
14	09.10	10.20
15	12.10	13.20
	CREW	CHANGE
16	14.35	15.45
17	17.35	18.45
18	20.00	21.10

BUS # 4		

19	07.55	09.05
20	10.25	11.35
21	13.20	14.30
	CREW	CHANGE
22	15.50	17.00
23	18.45	19.55
24	21.15	22.25

TABLE 4.15 TIME TABLE FOR ROUTE NO.14

ROUTE # : 14 RAWATA TO TILAK NAGAR		
ROUTE TYPE : 1	NO. OF BUSES :	5
NO. OF ROUND TRIPS BY EACH BUS :		4
NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE:		2

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	06.00	07.35
2	09.54	11.29
	CREW	CHANGE
3	13.52	15.27
4	17.20	18.55

BUS # 2		

5	07.08	08.43
6	11.02	12.37
	CREW	CHANGE
7	15.00	16.35
8	18.28	20.03

BUS # 3		

9	07.42	09.17
10	11.36	13.11
	CREW	CHANGE
11	15.34	17.09
12	19.02	20.37

BUS # 4		

13	08.16	09.51
14	12.10	13.45
	CREW	CHANGE
15	16.08	17.43
16	19.36	21.11

BUS # 5		

17	08.50	10.25
18	12.44	14.19
	CREW	CHANGE
19	16.42	18.17
20	20.10	21.45

TABLE 4.16 TIME TABLE FOR ROUTE NO.15

ROUTE # : 15 VIKASPURI H-3 TO NIZAMUDDIN RLY. STATION			
ROUTE TYPE : 2		NO. OF BUSES : 6	
NO. OF SINGLE TRIPS BY EACH BUS :			10
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			5
S_NO.	DEP.TIME AT ORIGIN TERM.	DIREC -TION	DEP.TIME AT DESTN.TERM.

BUS # 1			
1	05.30	1	07.05
2	07.18	2	08.53
3	09.06	1	10.41
4	11.24	2	12.59
5	13.00	1	14.35
	CREW		CHANGE
6	14.48	2	16.23
7	17.06	1	18.41
8	18.42	2	20.17
9	20.30	1	22.05
10	22.18	2	23.53

BUS # 2			

11	05.30	2	07.05
12	07.18	1	08.53
13	09.06	2	10.41
14	11.24	1	12.59
15	13.00	2	14.35
	CREW		CHANGE
16	14.48	1	16.23
17	17.06	2	18.41
18	18.42	1	20.17
19	20.30	2	22.05
20	22.18	1	23.53

BUS # 3			

21	06.06	1	07.41
22	07.54	2	09.29
23	09.42	1	11.17
24	12.00	2	13.35
25	13.36	1	15.11
	CREW		CHANGE
26	15.24	2	16.59
27	17.42	1	19.17
28	19.18	2	20.53
29	21.06	1	22.41
30	22.54	2	00.29

Contd..

TABLE 4.16 (Contd.)

BUS # 4

31	06.06	2	07.41
32	07.54	1	09.29
33	09.42	2	11.17
34	12.00	1	13.35
35	13.36	2	15.11
	CREW		CHANGE
36	15.24	1	16.59
37	17.42	2	19.17
38	19.18	1	20.53
39	21.06	2	22.41
40	22.54	1	00.29

BUS # 5

41	06.42	1	08.17
42	08.30	2	10.05
43	10.18	1	11.53
44	12.36	2	14.11
45	14.12	1	15.47
	CREW		CHANGE
46	16.00	2	17.35
47	18.18	1	19.53
48	19.54	2	21.29
49	21.42	1	23.17
50	23.30	2	01.05

BUS # 6

51	06.42	2	08.17
52	08.30	1	10.05
53	10.18	2	11.53
54	12.36	1	14.11
55	14.12	2	15.47
	CREW		CHANGE
56	16.00	1	17.35
57	18.18	2	19.53
58	19.54	1	21.29
59	21.42	2	23.17
60	23.30	1	01.05

TABLE 4.17 TIME TABLE FOR ROUTE NO.16

ROUTE # : 16 MUKHMELPUR TO ISBT		
ROUTE TYPE : 1	NO. OF BUSES :	5
NO. OF ROUND TRIPS BY EACH BUS :		6
NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE:		3

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	05.30	06.50
2	08.48	10.08
3	12.04	13.24
	CREW	CHANGE
4	15.20	16.40
5	18.36	19.56
6	21.22	22.42

BUS # 2		

7	06.26	07.46
8	09.44	11.04
9	13.00	14.20
	CREW	CHANGE
10	16.16	17.36
11	19.32	20.52
12	22.18	23.38

BUS # 3		

13	07.22	08.42
14	10.40	12.00
15	13.56	15.16
	CREW	CHANGE
16	17.12	18.32
17	20.28	21.48
18	23.14	00.34

BUS # 4		

19	07.50	09.10
20	11.08	12.28
21	14.24	15.44
	CREW	CHANGE
22	17.40	19.00
23	20.56	22.16
24	23.42	01.02

BUS # 5		

25	08.18	09.38
26	11.36	12.56
27	14.52	16.12
	CREW	CHANGE
28	18.08	19.28
29	21.24	22.44
30	24.10	01.30

TABLE 4.18 TIME TABLE FOR ROUTE NO.17

ROUTE # : 17 NAND NAGARI TO RANIBAGH/MAHINDRA PARK		
ROUTE TYPE : 1	NO. OF BUSES :	5
NO. OF ROUND TRIPS BY EACH BUS :		6
NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE:		3

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	05.00	06.10
2	07.20	08.30
3	10.08	11.18
	CREW	CHANGE
4	12.28	13.38
5	15.16	16.26
6	17.36	18.46

BUS # 2		

7	05.56	07.06
8	08.16	09.26
9	11.04	12.14
	CREW	CHANGE
10	13.24	14.34
11	16.12	17.22
12	18.32	19.42

BUS # 3		

13	06.52	08.02
14	09.12	10.22
15	12.00	13.10
	CREW	CHANGE
16	14.20	15.30
17	17.08	18.18
18	19.28	20.38

BUS # 4		

19	07.48	08.58
20	10.08	11.18
21	12.56	14.06
	CREW	CHANGE
22	15.16	16.26
23	18.04	19.14
24	20.24	21.34

BUS # 5		

25	08.44	09.54
26	11.04	12.14
27	13.52	15.02
	CREW	CHANGE
28	16.12	17.22
29	19.00	20.10
30	21.20	22.30

TABLE 4.19 TIME TABLE FOR ROUTE NO.18

ROUTE # : 18 RANIBAGH TO RANIBAGH			
ROUTE TYPE : 3		NO. OF BUSES :	6
NO. OF SINGLE TRIPS BY EACH BUS :			16
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			8

S_NO.	DEP.TIME AT THE TERM.	DIREC -TION	ARVL.TIME AT THE TERM.

BUS # 1			

1	05.00	1	06.00
2	06.00	1	07.00
3	07.00	1	08.00
4	08.00	1	09.00
5	09.00	1	10.00
6	10.30	1	11.30
7	11.30	1	12.30
8	12.30	1	13.30
	CREW		CHANGE
9	13.30	1	14.30
10	14.30	1	15.30
11	16.00	1	17.00
12	17.00	1	18.00
13	18.00	1	19.00
14	19.00	1	20.00
15	20.00	1	21.00
16	21.00	1	22.00

BUS # 2			

17	05.00	2	06.00
18	06.00	2	07.00
19	07.00	2	08.00
20	08.00	2	09.00
21	09.00	2	10.00
22	10.30	2	11.30
23	11.30	2	12.30
24	12.30	2	13.30
	CREW		CHANGE
25	13.30	2	14.30
26	14.30	2	15.30
27	16.00	2	17.00
28	17.00	2	18.00
29	18.00	2	19.00
30	19.00	2	20.00
31	20.00	2	21.00
32	21.00	2	22.00

Contd..

TABLE 4.19 (Contd.)

BUS # 3

33	05.30	1	06.30
34	06.30	1	07.30
35	07.30	1	08.30
36	08.30	1	09.30
37	09.30	1	10.30
38	11.00	1	12.00
39	12.00	1	13.00
40	13.00	1	14.00

CREW

CHANGE

41	14.00	1	15.00
42	15.00	1	16.00
43	16.30	1	17.30
44	17.30	1	18.30
45	18.30	1	19.30
46	19.30	1	20.30
47	20.30	1	21.30
48	21.30	1	22.30

BUS # 4

49	05.30	2	06.30
50	06.30	2	07.30
51	07.30	2	08.30
52	08.30	2	09.30
53	09.30	2	10.30
54	11.00	2	12.00
55	12.00	2	13.00
56	13.00	2	14.00

CREW

CHANGE

57	14.00	2	15.00
58	15.00	2	16.00
59	16.30	2	17.30
60	17.30	2	18.30
61	18.30	2	19.30
62	19.30	2	20.30
63	20.30	2	21.30
64	21.30	2	22.30

Contd..

TABLE 4.19 (Contd.)

BUS # 5

65	07.15	1	08.15
66	08.15	1	09.15
67	09.15	1	10.15
68	10.15	1	11.15
69	11.15	1	12.15
70	12.45	1	13.45
71	13.45	1	14.45
72	14.45	1	15.45
	CREW		CHANGE
73	15.45	1	16.45
74	16.45	1	17.45
75	18.15	1	19.15
76	19.15	1	20.15
77	20.15	1	21.15
78	21.15	1	22.15
79	22.15	1	23.15
80	23.15	1	00.15

BUS # 6

81	07.15	2	08.15
82	08.15	2	09.15
83	09.15	2	10.15
84	10.15	2	11.15
85	11.15	2	12.15
86	12.45	2	13.45
87	13.45	2	14.45
88	14.45	2	15.45
	CREW		CHANGE
89	15.45	2	16.45
90	16.45	2	17.45
91	18.15	2	19.15
92	19.15	2	20.15
93	20.15	2	21.15
94	21.15	2	22.15
95	22.15	2	23.15
96	23.15	2	00.15

TABLE 4.20 TIME TABLE FOR ROUTE NO.19

ROUTE # : 19 NAZAFGARH TO NIZAMUDDIN RLY. STATION			
ROUTE TYPE : 2		NO. OF BUSES :	6
NO. OF SINGLE TRIPS BY EACH BUS :			10
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			5

S_NO.	DEP.TIME AT ORIGIN TERM.	DIREC -TION	DEP.TIME AT DESTN.TERM.

BUS # 1			

1	05.00	1	06.35
2	06.42	2	08.17
3	08.24	1	09.59
4	10.36	2	12.11
5	12.22	1	13.57
	CREW		CHANGE
6	14.04	2	15.39
7	16.16	1	17.51
8	18.02	2	19.37
9	19.44	1	21.19
10	21.26	2	23.01

BUS # 2			

11	05.00	2	06.35
12	06.42	1	08.17
13	08.24	2	09.59
14	10.36	1	12.11
15	12.22	2	13.57
	CREW		CHANGE
16	14.04	1	15.39
17	16.16	2	17.51
18	18.02	1	19.37
19	19.44	2	21.19
20	21.26	1	23.01

BUS # 3			

21	05.34	1	07.09
22	07.16	2	08.51
23	08.58	1	10.33
24	11.10	2	12.45
25	12.56	1	14.31
	CREW		CHANGE
26	14.38	2	16.13
27	16.50	1	18.25
28	18.36	2	20.11
29	20.18	1	21.53
30	22.00	2	23.35

Contd..

TABLE 4.20 (Contd.)

BUS # 4

31	05.34	2	07.09
32	07.16	1	08.51
33	08.58	2	10.33
34	11.10	1	12.45
35	12.56	2	14.31
	CREW		CHANGE
36	14.38	1	16.13
37	16.50	2	18.25
38	18.36	1	20.11
39	20.18	2	21.53
40	22.00	1	23.35

BUS # 5

41	06.08	1	07.43
42	07.50	2	09.25
43	09.32	1	11.07
44	11.44	2	13.19
45	13.30	1	15.05
	CREW		CHANGE
46	15.12	2	16.47
47	17.24	1	18.59
48	19.10	2	20.45
49	20.52	1	22.27
50	22.34	2	00.09

BUS # 6

51	06.08	2	07.43
52	07.50	1	09.25
53	09.32	2	11.07
54	11.44	1	13.19
55	13.30	2	15.05
	CREW		CHANGE
56	15.12	1	16.47
57	17.24	2	18.59
58	19.10	1	20.45
59	20.52	2	22.27
60	22.34	1	00.09

TABLE 4.21 TIME TABLE FOR ROUTE NO.20

ROUTE # : 20 BINDAPUR DDA FLATS TO RLY. STATION			
ROUTE TYPE : 2		NO. OF BUSES :	8
NO. OF SINGLE TRIPS BY EACH BUS :			7
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			4

S_NO.	DEP.TIME AT ORIGIN TERM.	DIREC -TION	DEP.TIME AT DESTN.TERM.

BUS # 1			

1	05.00	1	07.02
2	07.06	2	09.08
3	09.42	1	11.44
4	11.46	2	13.48
	CREW		CHANGE
5	14.22	1	16.24
6	16.26	2	18.28
7	19.02	1	21.04

BUS # 2			

8	05.00	2	07.02
9	07.06	1	09.08
10	09.42	2	11.44
11	11.46	1	13.48
	CREW		CHANGE
12	14.22	2	16.24
13	16.26	1	18.28
14	19.02	2	21.04

BUS # 3			

15	05.28	1	07.30
16	07.34	2	09.36
17	10.10	1	12.12
18	12.14	2	14.16
	CREW		CHANGE
19	14.50	1	16.52
20	16.54	2	18.56
21	19.30	1	21.32

BUS # 4			

22	05.28	2	07.30
23	07.34	1	09.36
24	10.10	2	12.12
25	12.14	1	14.16
	CREW		CHANGE
26	14.50	2	16.52
27	16.54	1	18.56
28	19.30	2	21.32

Contd..

TABLE 4.21 (contd.)

BUS # 5

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*****
29          05.56          1          07.58
30          08.02          2          10.04
31          10.38          1          12.40
32          12.42          2          14.44
              CREW                      CHANGE
33          15.18          1          17.20
34          17.22          2          19.24
35          19.58          1          22.00
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BUS # 6

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*****
36          05.56          2          07.58
37          08.02          1          10.04
38          10.38          2          12.40
39          12.42          1          14.44
              CREW                      CHANGE
40          15.18          2          17.20
41          17.22          1          19.24
42          19.58          2          22.00
-----

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BUS # 7

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*****
43          06.24          1          08.26
44          08.30          2          10.32
45          11.06          1          13.08
46          13.10          2          15.12
              CREW                      CHANGE
47          15.46          1          17.48
48          17.50          2          19.52
49          20.26          1          22.28
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BUS # 8

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*****
50          06.24          2          08.26
51          08.30          1          10.32
52          11.06          2          13.08
53          13.10          1          15.12
              CREW                      CHANGE
54          15.46          2          17.48
55          17.50          1          19.52
56          20.26          2          22.28
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TABLE 4.22 TIME TABLE FOR ROUTE NO.21

 ROUTE # : 21 MOHAN GARDEN TO MINTO ROAD
 ROUTE TYPE : 1 NO. OF BUSES : 4
 NO. OF ROUND TRIPS BY EACH BUS : 6
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 3

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	05.00	06.25
2	08.30	09.55
3	12.00	13.25
	CREW	CHANGE
4	15.30	16.55
5	19.00	20.25
6	22.00	23.25

 BUS # 2

7	05.30	06.55
8	09.00	10.25
9	12.30	13.55
	CREW	CHANGE
10	16.00	17.25
11	19.30	20.55
12	22.30	23.55

 BUS # 3

13	06.00	07.25
14	09.30	10.55
15	13.00	14.25
	CREW	CHANGE
16	16.30	17.55
17	20.00	21.25
18	23.00	00.25

 BUS # 4

19	06.30	07.55
20	10.00	11.25
21	13.30	14.55
	CREW	CHANGE
22	17.00	18.25
23	20.30	21.55
24	23.30	00.55

TABLE 4.23 TIME TABLE FOR ROUTE NO.22

ROUTE # : 22 MORI GATE TO MORI GATE			
ROUTE TYPE : 3		NO. OF BUSES :	6
NO. OF SINGLE TRIPS BY EACH BUS :			10
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			6

S_NO.	DEP.TIME AT THE TERM.	DIREC -TION	ARVL.TIME AT THE TERM.

BUS # 1			

1	05.12	1	06.37
2	07.00	1	08.25
3	08.30	1	09.55
4	10.30	1	11.55
5	12.06	1	13.31
6	13.36	1	15.01
	CREW	CHANGE	
7	15.36	1	17.01
8	17.12	1	18.37
9	18.42	1	20.07
10	20.42	1	22.07

BUS # 2			

11	05.12	2	06.37
12	07.00	2	08.25
13	08.30	2	09.55
14	10.30	2	11.55
15	12.06	2	13.31
16	13.36	2	15.01
	CREW	CHANGE	
17	15.36	2	17.01
18	17.12	2	18.37
19	18.42	2	20.07
20	20.42	2	22.07

BUS # 3			

21	05.48	1	07.13
22	07.18	1	08.43
23	08.48	1	10.13
24	10.48	1	12.13
25	12.24	1	13.49
26	13.54	1	15.19
	CREW	CHANGE	
27	15.54	1	17.19
28	17.30	1	18.55
29	19.00	1	20.25
30	21.00	1	22.25

Contd..

TABLE 4.23 (Contd.)

BUS # 4

31	05.48	2	07.13
32	07.18	2	08.43
33	08.48	2	10.13
34	10.48	2	12.13
35	12.24	2	13.49
36	13.54	2	15.19
	CREW	CHANGE	
37	15.54	2	17.19
38	17.30	2	18.55
39	19.00	2	20.25
40	21.00	2	22.25

BUS # 5

41	06.24	1	07.49
42	07.54	1	09.19
43	09.24	1	10.49
44	11.24	1	12.49
45	13.00	1	14.25
46	14.30	1	15.55
	CREW	CHANGE	
47	16.30	1	17.55
48	18.06	1	19.31
49	19.36	1	21.01
50	21.36	1	23.01

BUS # 6

51	06.24	2	07.49
52	07.54	2	09.19
53	09.24	2	10.49
54	11.24	2	12.49
55	13.00	2	14.25
56	14.30	2	15.55
	CREW	CHANGE	
57	16.30	2	17.55
58	18.06	2	19.31
59	19.36	2	21.01
60	21.36	2	23.01

TABLE 4.24 TIME TABLE FOR ROUTE NO.23

ROUTE # : 23 NAZAFGARH TO ISBT		
ROUTE TYPE : 1		NO. OF BUSES : 6
NO. OF ROUND TRIPS BY EACH BUS :		8
NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE:		4

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	05.00	06.00
2	07.00	08.00
3	09.30	10.30
4	11.30	12.30
	CREW	CHANGE
5	14.00	15.00
6	16.00	17.00
7	18.30	19.30
8	20.30	21.30

BUS # 2		

9	05.30	06.30
10	07.30	08.30
11	10.00	11.00
12	12.00	13.00
	CREW	CHANGE
13	14.30	15.30
14	16.30	17.30
15	19.00	20.00
16	21.00	22.00

BUS # 3		

17	06.00	07.00
18	08.00	09.00
19	10.30	11.30
20	12.30	13.30
	CREW	CHANGE
21	15.00	16.00
22	17.00	18.00
23	19.30	20.30
24	21.30	22.30

BUS # 4		

25	06.30	07.30
26	08.30	09.30
27	11.00	12.00
28	13.00	14.00
	CREW	CHANGE
29	15.30	16.30
30	17.30	18.30
31	20.00	21.00
32	22.00	23.00

Contd..

TABLE 4.24 (Contd.)

BUS # 5

33	07.15	08.15
34	09.15	10.15
35	11.45	12.45
36	13.45	14.45
	CREW	CHANGE
37	16.15	17.15
38	18.15	19.15
39	20.45	21.45
40	22.45	23.45

BUS # 6

41	07.45	08.45
42	09.45	10.45
43	12.15	13.15
44	14.15	15.15
	CREW	CHANGE
45	16.45	17.45
46	18.45	19.45
47	21.15	22.15
48	23.15	00.15

TABLE 4.25 TIME TABLE FOR ROUTE NO.24

ROUTE # : 24 OKHLA TO OKHLA
 ROUTE TYPE : 3 NO. OF BUSES : 6
 NO. OF SINGLE TRIPS BY EACH BUS : 12
 NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE: 6

S_NO.	DEP.TIME AT THE TERM.	DIREC -TION	ARVL.TIME AT THE TERM.
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BUS # 1

1	05.30	1	06.50
2	07.06	1	08.26
3	08.26	1	09.46
4	10.16	1	11.36
5	11.38	1	12.58
6	12.58	1	14.18
CREW		CHANGE	
7	14.48	1	16.08
8	16.10	1	17.30
9	17.30	1	18.50
10	19.20	1	20.40
11	20.42	1	22.02
12	22.02	1	23.22

BUS # 2

13	05.30	2	06.50
14	07.06	2	08.26
15	08.26	2	09.46
16	10.16	2	11.36
17	11.38	2	12.58
18	12.58	2	14.18
CREW		CHANGE	
19	14.48	2	16.08
20	16.10	2	17.30
21	17.30	2	18.50
22	19.20	2	20.40
23	20.42	2	22.02
24	22.02	2	23.22

BUS # 3

25	06.02	1	07.22
26	07.22	1	08.42
27	08.42	1	10.02
28	10.32	1	11.52
29	11.54	1	13.14
30	13.14	1	14.34
CREW		CHANGE	
31	15.04	1	16.24
32	16.26	1	17.46
33	17.46	1	19.06
34	19.36	1	20.56
35	20.58	1	22.18
36	22.18	1	23.38

Contd..

TABLE 4.25 (Contd.)

BUS # 4

37	06.02	2	07.22
38	07.22	2	08.42
39	08.42	2	10.02
40	10.32	2	11.52
41	11.54	2	13.14
42	13.14	2	14.34
	CREW		CHANGE
43	15.04	2	16.24
44	16.26	2	17.46
45	17.46	2	19.06
46	19.36	2	20.56
47	20.58	2	22.18
48	22.18	2	23.38

BUS # 5

49	06.34	1	07.54
50	07.54	1	09.14
51	09.14	1	10.34
52	11.04	1	12.24
53	12.26	1	13.46
54	13.46	1	15.06
	CREW		CHANGE
55	15.36	1	16.56
56	16.58	1	18.18
57	18.18	1	19.38
58	20.08	1	21.28
59	21.30	1	22.50
60	22.50	1	00.10

BUS # 6

61	06.34	2	07.54
62	07.54	2	09.14
63	09.14	2	10.34
64	11.04	2	12.24
65	12.26	2	13.46
66	13.46	2	15.06
	CREW		CHANGE
67	15.36	2	16.56
68	16.58	2	18.18
69	18.18	2	19.38
70	20.08	2	21.28
71	21.30	2	22.50
72	22.50	2	00.10

TABLE 4.26 TIME TABLE FOR ROUTE NO.25

ROUTE # : 25 SAFDARJUNG(T) TO SAFDARJUNG(T)			
ROUTE TYPE : 3		NO. OF BUSES :	6
NO. OF SINGLE TRIPS BY EACH BUS :			10
NO. OF SINGLE TRIPS BY EACH BUS BEFORE CREW CHANGE:			5

S_NO.	DEP.TIME AT THE TERM.	DIREC -TION	ARVL.TIME AT THE TERM.

BUS # 1			

1	05.00	1	06.35
2	06.42	1	08.17
3	08.24	1	09.59
4	10.36	1	12.11
5	12.22	1	13.57
	CREW		CHANGE
6	14.04	1	15.39
7	16.16	1	17.51
8	18.02	1	19.37
9	19.44	1	21.19
10	21.26	1	23.01

BUS # 2			

11	05.00	2	06.35
12	06.42	2	08.17
13	08.24	2	09.59
14	10.36	2	12.11
15	12.22	2	13.57
	CREW		CHANGE
16	14.04	2	15.39
17	16.16	2	17.51
18	18.02	2	19.37
19	19.44	2	21.19
20	21.26	2	23.01

BUS # 3			

21	05.34	1	07.09
22	07.16	1	08.51
23	08.58	1	10.33
24	11.10	1	12.45
25	12.56	1	14.31
	CREW		CHANGE
26	14.38	1	16.13
27	16.50	1	18.25
28	18.36	1	20.11
29	20.18	1	21.53
30	22.00	1	23.35

Contd..

TABLE 4.26 (Contd.)

BUS # 4

31	05.34	2	07.09
32	07.16	2	08.51
33	08.58	2	10.33
34	11.10	2	12.45
35	12.56	2	14.31
	CREW		CHANGE
36	14.38	2	16.13
37	16.50	2	18.25
38	18.36	2	20.11
39	20.18	2	21.53
40	22.00	2	23.35

BUS # 5

41	06.08	1	07.43
42	07.50	1	09.25
43	09.32	1	11.07
44	11.44	1	13.19
45	13.30	1	15.05
	CREW		CHANGE
46	15.12	1	16.47
47	17.24	1	18.59
48	19.10	1	20.45
49	20.52	1	22.27
50	22.34	1	00.09

BUS # 6

51	06.08	2	07.43
52	07.50	2	09.25
53	09.32	2	11.07
54	11.44	2	13.19
55	13.30	2	15.05
	CREW		CHANGE
56	15.12	2	16.47
57	17.24	2	18.59
58	19.10	2	20.45
59	20.52	2	22.27
60	22.34	2	00.09

TABLE 4.27 TIME TABLE FOR ROUTE NO.26

 ROUTE # : 26 NARELA MANDI TO FATEHPURI
 ROUTE TYPE : 1 NO. OF BUSES : 5
 NO. OF ROUND TRIPS BY EACH BUS : 4
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 2

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		
1	05.30	07.25
2	10.00	11.55
	CREW	CHANGE
3	14.30	16.25
4	18.30	20.25

BUS # 2		

5	07.00	08.55
6	11.30	13.25
	CREW	CHANGE
7	16.00	17.55
8	20.00	21.55

BUS # 3		

9	07.30	09.25
10	12.00	13.55
	CREW	CHANGE
11	16.30	18.25
12	20.30	22.25

BUS # 4		

13	08.00	09.55
14	12.30	14.25
	CREW	CHANGE
15	17.00	18.55
16	21.00	22.55

BUS # 5		

17	08.30	10.25
18	13.00	14.55
	CREW	CHANGE
19	17.30	19.25
20	21.30	23.25

TABLE 4.25 TIME TABLE FOR ROUTE NO.27

ROUTE # : 27 JHEEL TO DERA VILLAGE		
ROUTE TYPE : 1	NO. OF BUSES :	5
NO. OF ROUND TRIPS BY EACH BUS :		4
NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE:		2

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	05.10	07.00
2	09.40	11.30
	CREW	CHANGE
3	13.50	15.40
4	17.50	19.40

BUS # 2		

5	06.30	08.20
6	11.00	12.50
	CREW	CHANGE
7	15.10	17.00
8	19.10	21.00

BUS # 3		

9	07.50	09.40
10	12.20	14.10
	CREW	CHANGE
11	16.30	18.20
12	20.30	22.20

BUS # 4		

13	08.30	10.20
14	13.00	14.50
	CREW	CHANGE
15	17.10	19.00
16	21.10	23.00

BUS # 5		

17	09.10	11.00
18	13.40	15.30
	CREW	CHANGE
19	18.30	20.20
20	22.30	00.20

TABLE 4.29 TIME TABLE FOR ROUTE NO.28

 ROUTE # : 28 TUGLAKABAD RLY.STN. TO OLD DELHI RLY.STN.
 ROUTE TYPE : 1 NO. OF BUSES : 5
 NO. OF ROUND TRIPS BY EACH BUS : 4
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 2

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		
1	06.05	07.40
2	09.47	11.22
	CREW	CHANGE
3	13.31	15.06
4	16.45	18.20

BUS # 2		

5	07.09	08.44
6	10.51	12.26
	CREW	CHANGE
7	14.35	16.10
8	17.49	19.24

BUS # 3		

9	07.41	09.16
10	11.23	12.58
	CREW	CHANGE
11	15.07	16.42
12	18.21	19.56

BUS # 4		

13	08.13	09.48
14	11.55	13.30
	CREW	CHANGE
15	15.39	17.14
16	18.53	20.28

BUS # 5		

17	08.45	10.20
18	12.27	14.02
	CREW	CHANGE
19	16.11	17.46
20	19.25	21.00

TABLE 4.30 TIME TABLE FOR ROUTE NO.29

 ROUTE # : 29 YAMUNA VIHAR C-4 TO R.K.PURAM
 ROUTE TYPE : 1 NO. OF BUSES : 5
 NO. OF ROUND TRIPS BY EACH BUS : 6
 NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE: 3

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		
1	05.00	06.10
2	07.20	08.30
3	10.08	11.18
	CREW	CHANGE
4	12.28	13.38
5	15.16	16.26
6	17.36	18.46

BUS # 2		

7	05.58	07.08
8	08.18	09.28
9	11.04	12.14
	CREW	CHANGE
10	13.24	14.34
11	16.12	17.22
12	18.32	19.42

BUS # 3		

13	06.52	08.02
14	09.12	10.22
15	12.00	13.10
	CREW	CHANGE
16	14.20	15.30
17	17.08	18.18
18	19.28	20.38

BUS # 4		

19	07.48	08.58
20	10.08	11.18
21	12.56	14.06
	CREW	CHANGE
22	15.16	16.26
23	18.04	19.14
24	20.24	21.34

BUS # 5		

25	08.44	09.54
26	11.04	12.14
27	13.52	15.02
	CREW	CHANGE
28	16.12	17.22
29	19.00	20.10
30	21.20	22.30

TABLE 4.31 TIME TABLE FOR ROUTE NO.30

ROUTE # : 30 JARODA KALAN TO C.SEC.		
ROUTE TYPE : 1	NO. OF BUSES :	5
NO. OF ROUND TRIPS BY EACH BUS :		4
NO. OF ROUND TRIPS BY EACH BUS BEFORE CREW CHANGE:		2

S_NO.	DEP.TIME AT TERM.-1	DEP.TIME AT TERM.-2

BUS # 1		

1	06.00	07.40
2	10.00	11.40
	CREW	CHANGE
3	14.00	15.40
4	17.30	19.10

BUS # 2		

5	07.00	08.40
6	11.00	12.40
	CREW	CHANGE
7	15.00	16.40
8	18.30	20.10

BUS # 3		

9	07.30	09.10
10	11.30	13.10
	CREW	CHANGE
11	15.30	17.10
12	19.00	20.40

BUS # 4		

13	08.00	09.40
14	12.00	13.40
	CREW	CHANGE
15	16.00	17.40
16	19.30	21.10

BUS # 5		

17	08.30	10.10
18	12.30	14.10
	CREW	CHANGE
19	16.30	18.10
20	20.00	21.40

BUS # 6		

21	09.00	10.40
22	13.00	14.40
	CREW	CHANGE
23	17.00	18.40
24	20.30	22.10

5. SUMMARY AND CONCLUSIONS

5.1 SUMMARY AND CONCLUSIONS

The development of the package is aimed to provide a tool in hands of transport planner to prepare the time table of a bus transit system, that provides an efficient operation of the buses on the route network along with satisfying all the practical constraints related to operational strategies and labour laws prevailing in the country. This package prepares the time table for each route in tabular form showing the departure times of the buses from the terminals. This also displays the graphic picture of movement of the buses from one terminal to other at their departure times.

Three types of routes are considered as following:

Type I : Straight (non-circular) route having a terminal at its one end only.

Type II : Straight (non-circular) route having a terminal at each end.

Type III : Circular route having the same origin and destination terminal.

Some input elements like rest period, rest time, crew change time are taken as constant for all the routes, as these are standard values as per the labour laws. The input data which are variables for different routes are, type of the route, start time, end time, mid time, headway, layover time, travel time and number of buses. For identification, the number of the route is also given as input.

Output of the program includes the bus identification numbers, departure times of the buses from the terminals, their direction of movement for each departure time, total number of trips made by each bus and number of trips before crew change, by each bus. To provide the complete information, the output shows the route number, type of the route and number of buses deployed on the route also.

The program is smart enough to decide about the rest to be provided to the crew. Sometimes a situation occurs when a bus has its turn to take rest but its next available departure time is such that its idle period is greater than the rest time. In such a case the program utilizes this idle period as rest time and no separate rest is to be provided. Sometimes a situation occurs when a bus is to be provided a rest just before its last trip. In such a case, practically a compromise can be settled with the crew and no rest is given, as after one trip only, operation will be off. The program handles these situations intelligently.

The package is fully interactive and guides the user at every step of execution. Options to feed the input from keyboard or an existing file and to get output directly on screen or in a file, are available. Every screen has option to proceed or to exit from the execution, and the user can terminate the execution at any stage.

The field data of 30 routes of Delhi metropolitan area are used to test the generality and rationality of the package. The results are found quite logical and consistent with actual operation strategies and constraints.

Conclusively, the package can be proved to be very useful tool in hands of the transport planner to prepare quickly an efficient and quite practical time table for a large bus transit system.

5.2 SCOPE FOR FUTURE STUDY

The suggestions for future study in this area are as below:

- (i) The present package considers only three types of routes which are independent of one another. A case may occur when two or more routes meet at a junction and then bifurcate. In such a case, an optimal time tabling is required to minimize the transfer time.
- (ii) Input data to be fed, are many in number. This number can be reduced by correlation between some parameters. For example, layover time could be correlated to the travel time.
- (iii) The package is UNIX based. This could be made DOS compatible.

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